SWE 432 -Web Application Development

Fall 2022

George Mason University

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Week 15:

Final Exam Review

Administrivia

- *HW Assignment 5* - Due 12/1 (today)!
- *Course Evaluations* - Open Until *Sunday December 4th*
- *Optional Final Exam Review Session:* During Office Hours Thursday (Today!) & Tuesday (12/6)
  - Thursday - React Review
  - Tuesday - User Centered Design Review

Final Exam

- Thursday, December 8th, 10:30am-1:15pm, This Room
- 3 Parts, In-class exam, closed book, 200 points total
  - ***Part 1:*** Multiple Choice Questions
  - ***Part 2:*** Short Answer
    - Either provide program output, or answer in a few short sentences
  - ***Part 3:*** Multi-Part Code Question (*implementing a simple Front-End in React*)
- Covers material from weeks 7-14, from both lectures and readings

Multiple Choice

- 75 Points -15 Questions
  - ~5 on React/CSS
  - ~2 on Deployment
  - ~8 on User-Centered Design
- Will Cover likely question material today

Short Answer

- 75 Points - 5 Questions
  - 1 Question on HTML/CSS (What is output)
  - 1 Question on Sketching and Prototyping
  - 1 Question on applying Heuristic Evaluation
  - 1 Question on Critiquing Visual Design
  - 1 Question on UI Evaluations
- Will Cover likely question material today

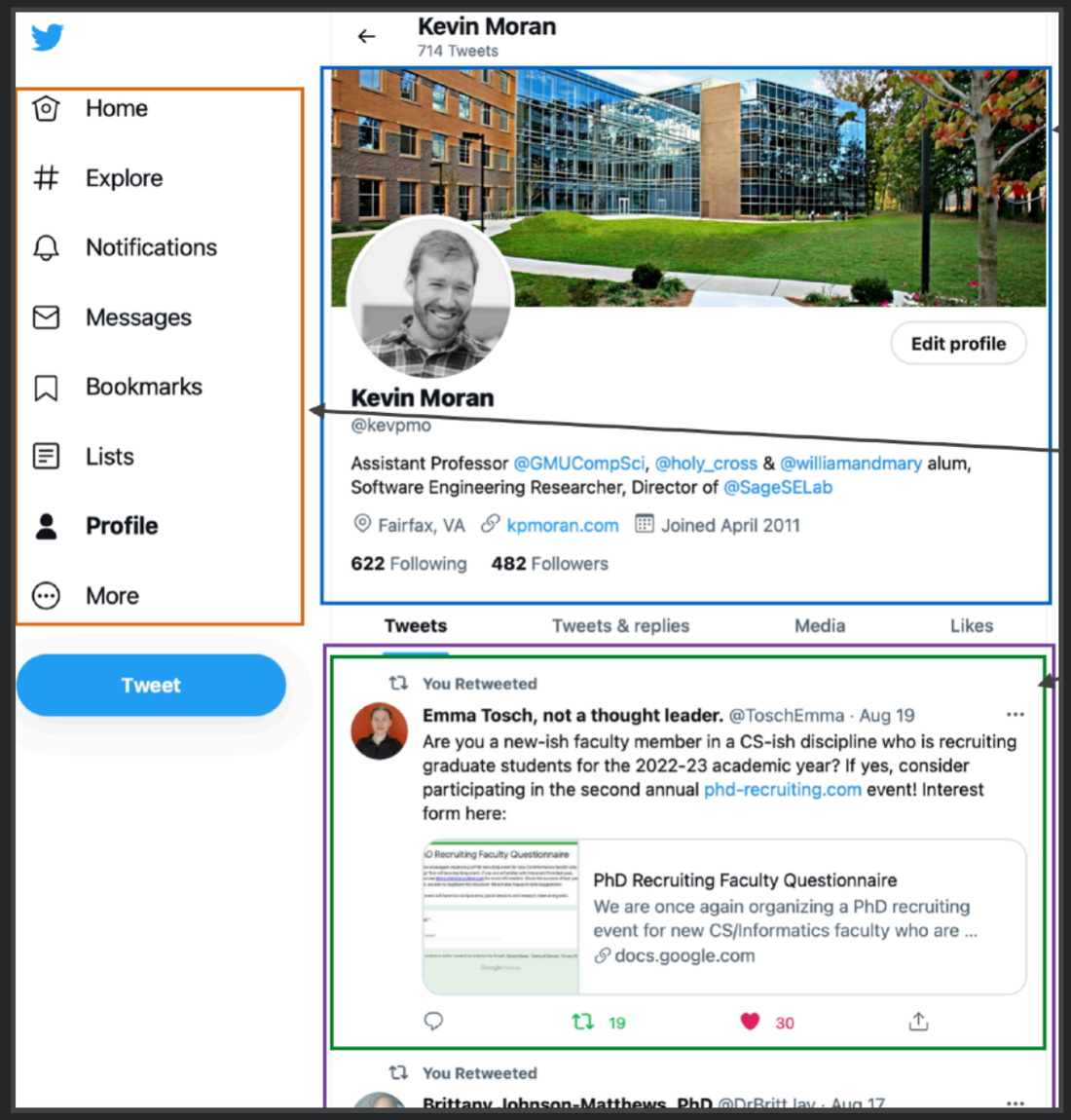
Coding Question

- 50 Points - 1 Question (Multiple Parts)
  - Implement a React Component
  - Will have interaction between two components
    - We will provide Example Code
    - You are free to use either Class-based or Functional Components (example code will be provided for both)
- I will provide an example question

Week 9 - React

Review: Components

- Web pages are complex, with lots of logic and presentation
- How can we organize web page to maximize modularity?
- Solution: Components
  - Templates that correspond to a specific widget
  - Encapsulates related logic & presentation using language construct (e.g., class)



Anatomy of a React Component

```
class Toggle extends React.Component {
  constructor(props) {
    super(props);
    this.state = {isToggleOn: true};

    // This binding is necessary to make `this` work in the callback
    this.handleClick = this.handleClick.bind(this);
  }

  handleClick() {
    this.setState(prevState => ({ isToggleOn: !prevState.isToggleOn }));
  }

  render() {
    return (
      <button onClick={this.handleClick}>
        {this.state.isToggleOn ? 'ON' : 'OFF'}
      </button>
    );
  }
}

ReactDOM.render(
  <Toggle />, document.getElementById('root')
);
```

https://reactjs.org/docs/handling-events.html

What is state?

- All internal component data that, when changed, should trigger UI update
  - Stored as single JSON object this.state
- What isn’t state?
  - Anything that could be computed from state (redundant)
  - Other components - should build them in render
  - Data duplicated from properties.

Properties vs. State

- Properties should be ***immutable***.
  - Created through attributes when component is instantiated.
  - Should *never* update within component
  - Parent may create a new instance of component with new properties

```
class Welcome extends React.Component {
  render() {
    return <h1>Hello, {this.props.name}</h1>;
  }
}
```

- State ***changes*** to reflect the current state of the component.
  - Can (and should) change based on the current internal data of your component.

Working with State

- Constructor should initialize state of object

```
constructor(props) {
    super(props);
    this.state = {date: new Date()};
  }
```

- Use this.setState to update state

```
    this.setState({
      date: new Date()
    });
```

- Doing this (asynchronously) will eventually result in render being invoked
  - Multiple state updates may be batched together and result in a single render call (handled by the framework)

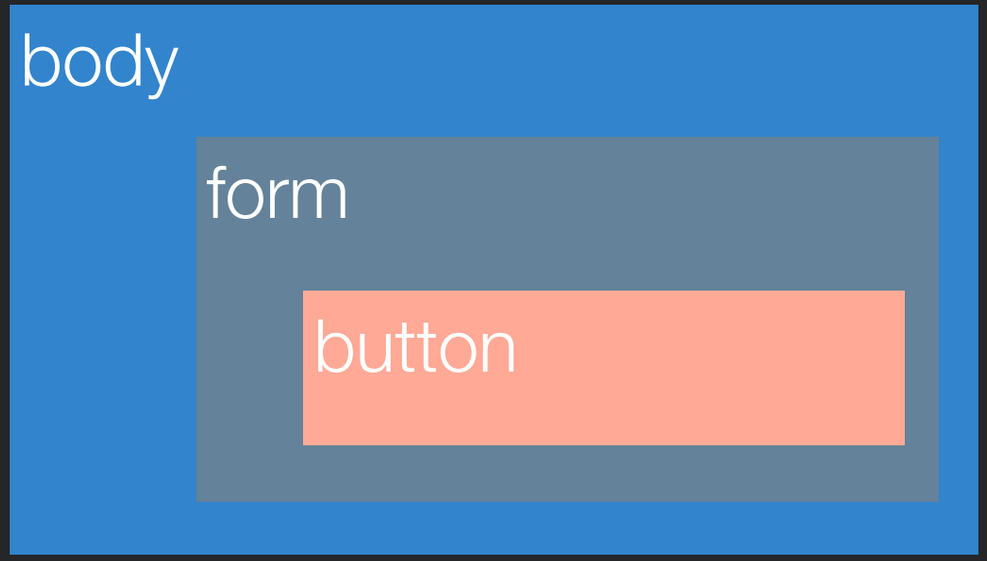
Handling Events

```jsx
class Toggle extends React.Component {
  constructor(props) {
    super(props);
    this.state = {isToggleOn: true};

    // This binding is necessary to make `this` work in the callback
    this.handleClick = this.handleClick.bind(this);
  }

  handleClick() {
    this.setState(prevState => ({ isToggleOn: !prevState.isToggleOn }));
  }

  render() {
    return (
      <button onClick={this.handleClick}>
        {this.state.isToggleOn ? 'ON' : 'OFF'}
      </button>
    );
  }
}

ReactDOM.render(
  <Toggle />, document.getElementById('root')
);
```

https://reactjs.org/docs/handling-events.html

Event Dispatching

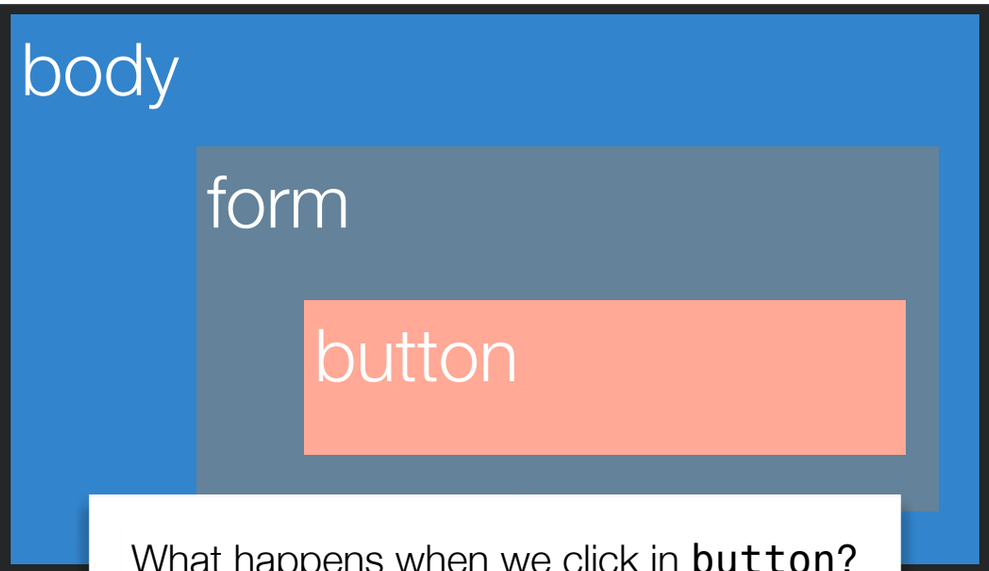
- Each event target can have (0…n) listeners registered for any given event type, called in arbitrary order
- What happens with nested elements?




```
Listener1: body onClick
Listener2: form onClick
Listener3: button onClick
```

What happens when we click in `button`?

Event Bubbling



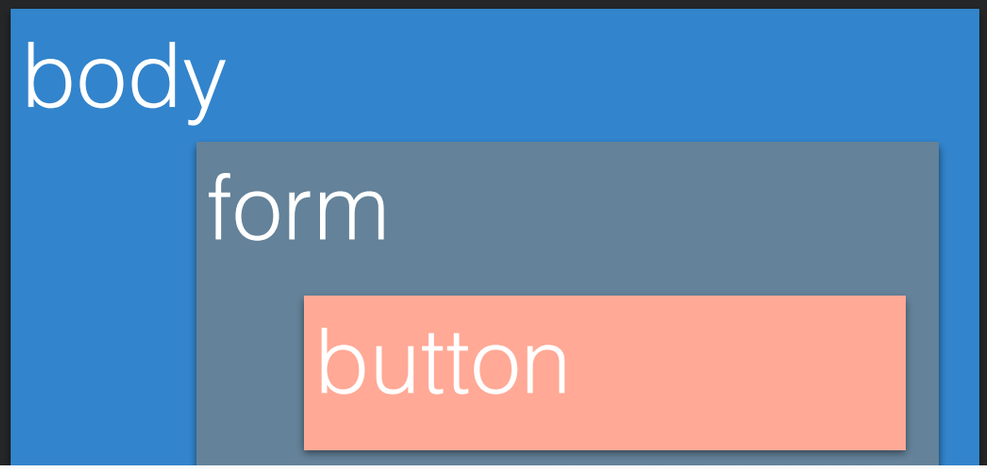
What happens when we click in `button`?

Called →

```
Listener1: body onClick
Listener2: form onClick
Listener3: button onClick
```

This is the default behavior

Event Capturing



What happens when we click in **`button`**?

Called →

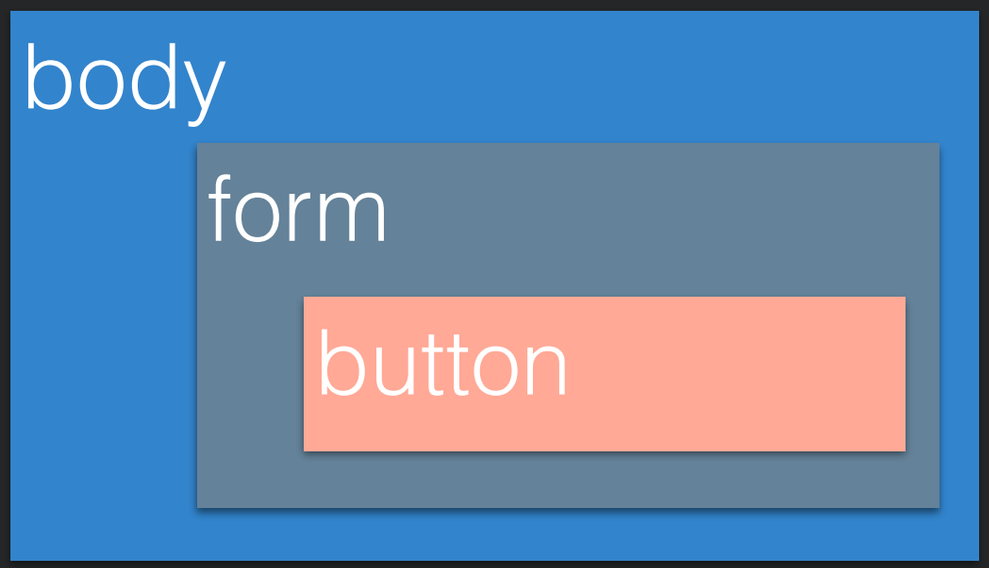
```
Listener1: body onClick
Listener2: form onClick
Listener3: button onClick
```

Enable event capturing when you register your listener:

```
element.addListener('click', myListener, true);
```

Event Dispatching

- An individual listener can stop bubbling/capturing by calling
- `event.stopPropagation();`
  - Assuming that `event` is the name of your handler's parameter




```
Listener1: body onClick
Listener2: form onClick
Listener3: button onClick
```

The Data Flows Down

- State that is common to multiple components should be owned by a common ancestor
  - State can be passed into descendants as properties
- When this state can manipulated by descendants (e.g., a control), change events should invoke a handler on common ancestor
  - Handler function should be passed to descendents

https://reactjs.org/docs/state-and-lifecycle.html#the-data-flows-down

The Data Flows Down

```
class Calculator extends React.Component {
  constructor(props) {
    super(props);
    this.handleCelsiusChange = this.handleCelsiusChange.bind(this);
    this.state = {temperature: '', scale: 'c'};
  }

  handleCelsiusChange(temperature) {
    this.setState({scale: 'c', temperature});
  }

  render() {
    const scale = this.state.scale;
    const temperature = this.state.temperature;
    const celsius = scale === 'f' ? tryConvert(temperature, toCelsius) : temperature;

    return (
      <div>
        <TemperatureInput
          scale="c"
          temperature={celsius}
          onTemperatureChange={this.handleCelsiusChange} />
      </div>
    );
  }
}
```

Nesting components

```
render() {
    return (
        <div>
            <PagePic pagename={this.props.pagename} />
            <PageLink pagename={this.props.pagename} />
        </div>
    );
}
```

Establishes ownership by creating in render function.

Sets pagename property of child to value of pagename property of parent

Controlled Components

```
class EssayForm extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      value: 'Please write an essay about your favorite DOM element.'
    };

    this.handleChange = this.handleChange.bind(this);
    this.handleSubmit = this.handleSubmit.bind(this);
  }

  handleChange(event) {
    this.setState({value: event.target.value});
  }

  handleSubmit(event) {
    alert('An essay was submitted: ' + this.state.value);
    event.preventDefault();
  }

  render() {
    return (
      <form onSubmit={this.handleSubmit}>
        <label>
          Name:
          <textarea value={this.state.value} onChange={this.handleChange} />
        </label>
        <input type="submit" value="Submit" />
      </form>
    );
  }
```

Controlled Components

- Single source of truth
- Whenever a control changes its value
  - React is notified
  - State is updated
- Whenever state is updated
  - If necessary, render function executes and generates control with new value

Reconciliation

```
<Card>
  <p>Paragraph 1</p>
  <p>Paragraph 2</p>
</Card>
```

```
<Card>
  <p>Paragraph 2</p>
</Card>
```

- Process by which React updates the DOM with each new render pass
- Occurs based on order of components
  - Second child of Card is destroyed.
  - First child of Card has text mutated.

https://reactjs.org/docs/reconciliation.html

Reconciliation with Keys

- Problem: what if children are dynamically generated and have their own state that must be persisted across render passes?
  - Don’t want children to be randomly transformed into other child with different state
- Solution: give children identity using keys
  - Children with keys will always keep identity, as updates will reorder them or destroy them if gone

Keys

```
function NumberList(props) {
  const numbers = props.numbers;
  const listItems = numbers.map((number) =>
    <li key={number.toString()}>
      {number}
    </li>
  );
  return (
    <ul>{listItems}</ul>
  );
}

const numbers = [1, 2, 3, 4, 5];
ReactDOM.render(
  <NumberList numbers={numbers} />,
  document.getElementById('root')
);
```

Functional Components + Hooks

But what if we want state + clean functional components??

```
import React, { Component } from 'react';

class Counter extends Component {
  constructor(props) {
    super(props);

    this.state = {
      count: 0,
    };
  }

  render() {
    return (
      <div>
        <p>You clicked {this.state.count} times</p>
        <button
          onClick={() =>
            this.setState({ count: this.state.count + 1 })
          }
        >
          Click me
        </button>
      </div>
    );
  }
}

export default Counter;
```

Functional Components + Hooks

Now we can have both with functional components + hooks!

```jsx
import React from 'react';

// how to use the state hook in a React function component
function Counter() {
  const [count, setCount] = React.useState(0);

  return (
    <div>
      <p>You clicked {count} times</p>
      <button onClick={() => setCount(count + 1)}>
        Click me
      </button>
    </div>
  );
}

export default Counter;
```

Week 10 - React & CSS

CSS: Cascading Style Sheets

- Language for ***styling*** documents

```
p {
    font-family: Arial;}
```

Property — Value

"Select all <p> elements"

Selector describes a *set* of HTML elements

"Use Arial font family"

Declaration indicates how selected elements should be styled.

- Separates *visual presentation* (CSS) from ***document structure*** (HTML)
  - Enables changes to one or the other.
  - Enables styles to be reused across sets of elements.

CSS Type Selectors

- What if we wanted more green?

```
h2, h3 {
    color: LightGreen;
}
```

"Select all <h2> and <h3> elements"

Type selector selects one or more element types.

```
* {
    color: LightGreen;
}
```

"Select all elements"

Universal selector selects all elements.

CSS Class Selectors

```
<img src="profilePic.jpg" class="imageLarge" />
```

"Label <img> element with imageLarge class"

```
.imageLarge {
    width: 200px;
    height: 200px;
}
```

"Define class imageLarge."

```
<img src="profilePic.jpg" class="imageLarge transparent" />
```

```
img.large {
    width: 200px;
    height: 200px;
}
```

"Define large class that applies only to <img> elements"

```
.transparent {
    opacity: .50;
}
```

"Define transparent class"

Classes enable the creation of sets of elements that can be styled in the same way.

CSS id Selectors

```html
<div id="exampleElem">
    Some text
</div>
```

```css
#exampleElem {
    font-weight: bold;
}
```

Some text

- ***Advantages***
  - Control presentation of individual elements
- ***Disadvantages***
  - Must write separate rule for *each* element

CSS Selectors

- **Key principles in designing effective styling rules:**
  - Use classes, semantic tags to create sets of elements that share a similar rules
  - Don’t repeat yourself (DRY)
    - Rather than create many identical or similar rules, apply single rule to all similar elements
- Match based on semantic properties, not styling
  - Matching elements based on their pre-existing styling is ***fragile***

Cascading Selectors

- What happens if more than one rule applies?
- Most *specific* rule takes precedence
  - ***p b*** is more specific than ***p***
  - ***#maximizeButton*** is more specific than ***button***
- If otherwise the same, *last* rule wins
- Enables writing generic rules that apply to many elements that are overriden by specific rules applying to a few elements

CSS Inheritance

- When an element is contained inside another element, some styling properties are inherited
  - e.g., font-family, color
- Some properties are not inherited
  - e.g., background-color, border
- Can force many properties to inherit value from parent using the inherit value
  - e.g., padding: inherit;

Pseudo Classes

```css
.invisible {
    display: none;
}

input:invalid {
    border: 2px solid red;
}

input:invalid + div {
    display: block;
}

input:focus + div {
    display: none;
}
```

```html
<label>
    Email: <input type="email" />
    <div class="invisible">Please enter a valid email.</div>
</label>
```

Email:

"Select elements with the invalid attribute."

"Select elements that have focus."

Classes that are automatically attached to elements based on their attributes.

Examples of Pseudo Classes

- :active - elements activated by user. For mouse clicks, occurs between mouse down and mouse up.
- :checked - radio, checkbox, option elements that are checked by user
- :disabled - elements that can’t receive focus
- :empty - elements with no children
- :focus - element that currently has the focus
- :hover - elements that are currently hovered over by mouse
- :invalid - elements that are currently invalid
- :link - link element that has not yet been visited
- :visited - link element that has been visited

Color

- Can set text color (color) and background color (background-color)
- Several ways to describe color
  - six digit hex code (e.g., #ee3e80)
  - color names: 147 predefined names
  - rgb(red, green, blue): amount of red, green, and blue
  - hsla(hue, saturation, lightness, alpha): alternative scheme for describing colors
- Can set opacity (opacity) from 0.0 to 1.0

```
body {
    color: Red;
    background-color: rgb(200, 200, 200); }
h1 {
    background-color: DarkCyan; }
h2 {
    color: #ee3e80; }
p {
    color: hsla(0, 100%, 100%, 0.5); }

div.overlay {
    opacity: 0.5; }
```

Typefaces

Serif

Sans-Serif

Monospace

Cursive

font-family: Georgia, Times, serif;

“Use Georgia if available, otherwise Times, otherwise any serif font”.

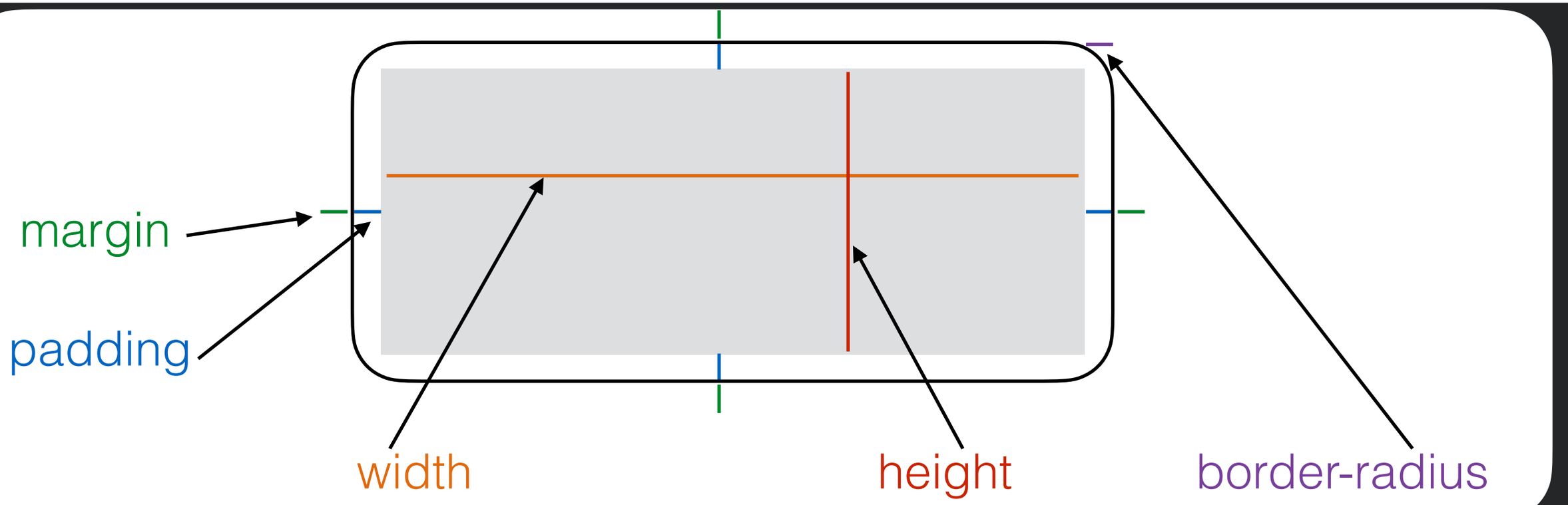
font-family enables the typeface to be specified. The typeface must be installed. Lists of fonts enable a browser to select an alternative.

Styling text

```css
h2 {
    text-transform: uppercase;
    text-decoration: underline;
    letter-spacing: 0.2em;
    text-align: center;
    line-height: 2em;
    vertical-align: middle;
    text-shadow: 1px 1px 0 #666666;

}
```

- text-transform: uppercase, lowercase, capitalize
- text-decoration: none, underline, overline, line-through, blink
- letter-spacing: space between letters (kerning)
- text-align: left, right, center, justify
- line-height: total of font height and empty space between lines
- vertical-align: top, middle, bottom, …
- text-shadow: [x offset][y offset][blur offset][color]

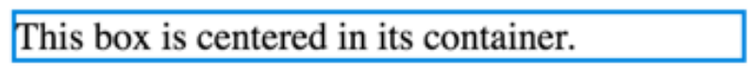
CSS "Box" Model



- Boxes, by default, are sized ***just*** large enough to fit their contents.
- Can specify sizes using `px` or `%`
  - % values are relative to the container dimensions
- margin: 10px 5px 10px 5px; (clockwise order - [top] [right] [bottom] [left])
- border: 3px dotted #0088dd; ([width] [style] [color])
  - style may be: solid, dotted,dashed, double, groove, ridge, inset, outset, hidden / none

Centering Content

```css
.centered {
    width: 300px;
    margin: 10px auto 10px auto;
    border: 2px solid #0088dd;
}
```



- How do you center an element inside a container?
- Step 1: Must first ensure that element is *narrower* than container.
  - By default, element will expand to fill entire container.
  - So must usually explicitly set width for element.
- Step 2: Use *auto* value for left and right to create equal gaps

Visibility and layout

- Can force elements to be inline or block element.
  - display: inline
  - display: block
- Can cause element to not be laid out or take up any space
  - display: none
  - *Very* useful for content that is dynamically added and removed.
- Can cause boxes to be invisible, but still take up space
  - visibility: hidden;

```
<ul>
    <li>Home</li>
    <li>Products</li>
    <li class="coming-soon">Services</li>
    <li>About</li>
    <li>Contact</li>
</ul>
```

```
li {
    display: inline;
    margin-right: 10px; }
li.coming-soon {
    display: none; }
```

Home Products About Contact

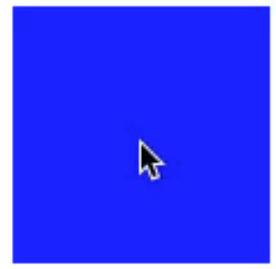
```
li {
    display: inline;
    margin-right: 10px; }
li.coming-soon {
    visibility: hidden; }
```

Home Products About Contact

Transitions

```css
.box {
    width: 100px;
    height: 100px;
    background-color: #0000FF;
    transition: width 2s, height 2s, background-color 2s, transform 2s;
}

.box:hover {
    background-color: #FFCCCC;
    width: 200px;
    height: 200px;
    transform: rotate(180deg);
}
```

```html
<div class="box"></div>
```

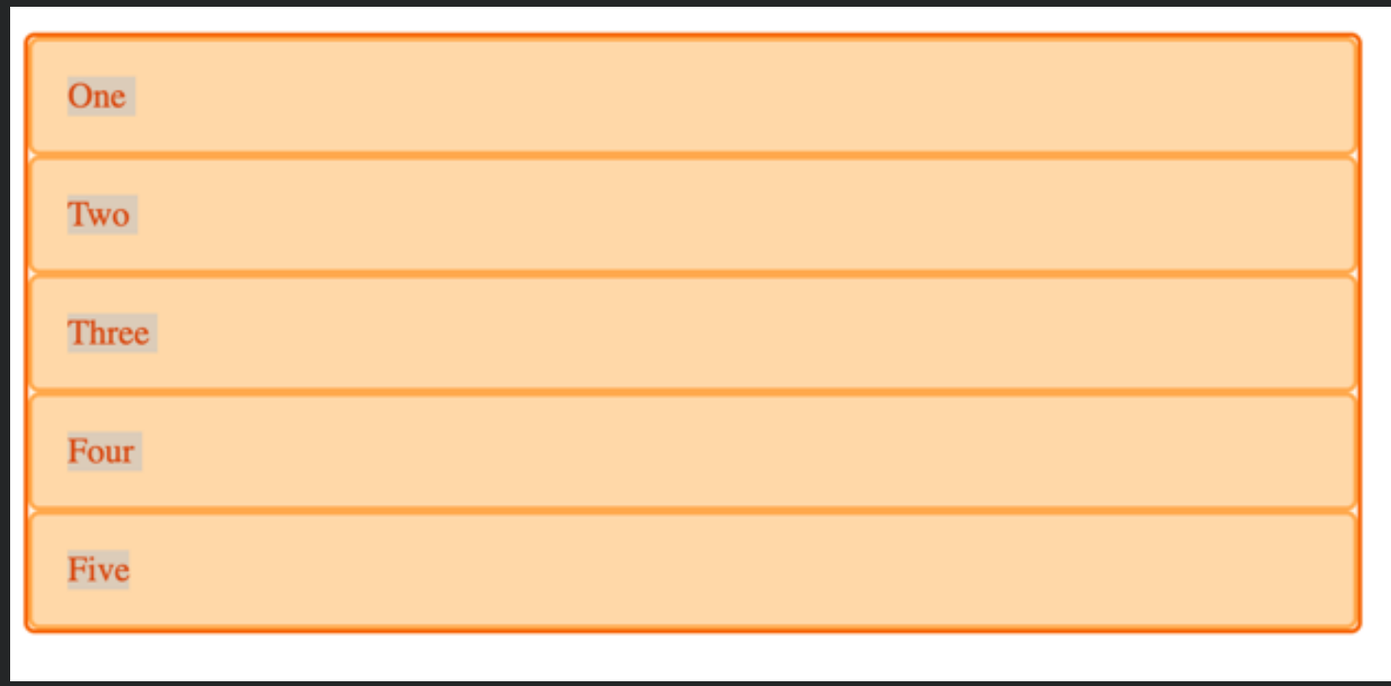


- transition: [property time], …, [property time]
  - When new class is applied, specifies the time it will take for each property to change
  - Can use *all* to select all changed properties

Grid layout

- Create using display: grid or display: inline-grid

```
<div class="wrapper">
  <div>One</div>
  <div>Two</div>
  <div>Three</div>
  <div>Four</div>
  <div>Five</div>
</div>


.wrapper {
  display: grid;
}
```

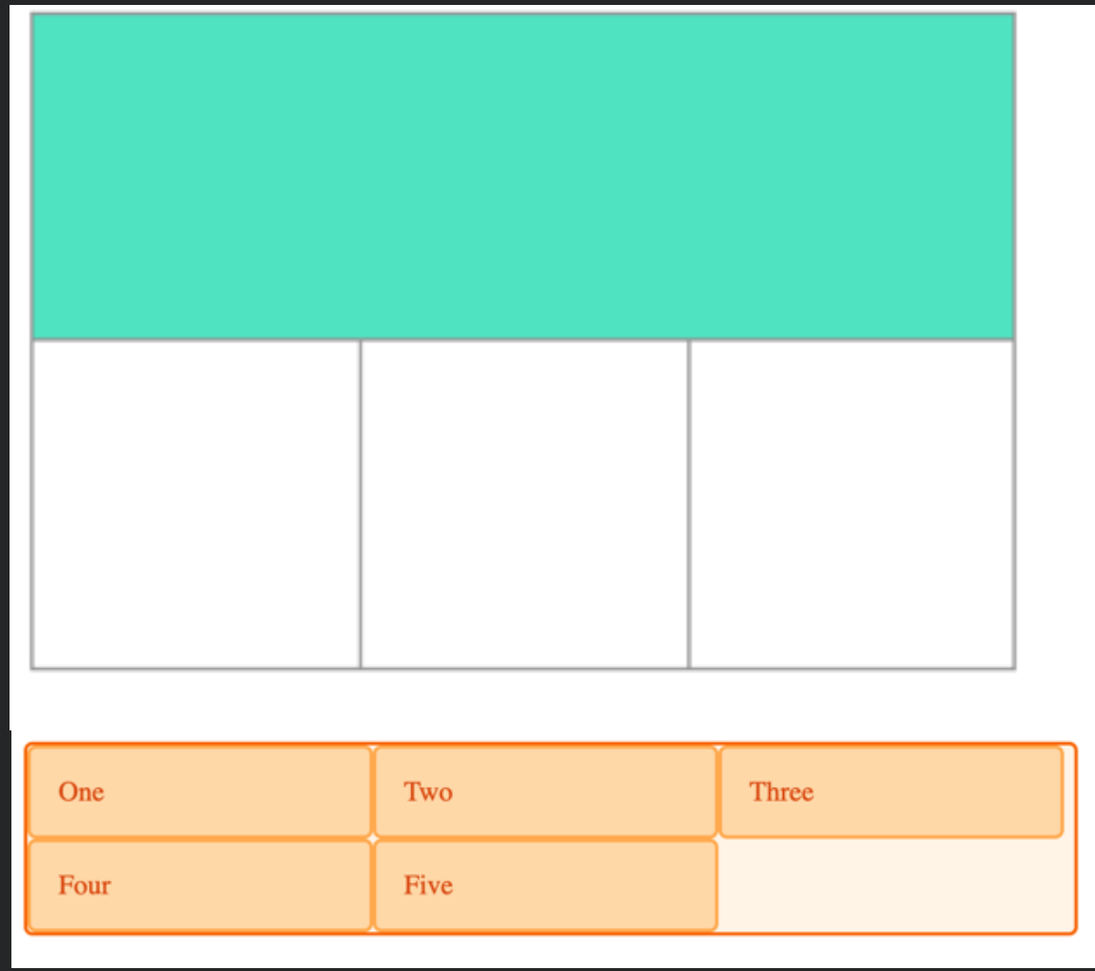


https://developer.mozilla.org/en-US/docs/Web/CSS/CSS_Grid_Layout/Basic_Concepts_of_Grid_Layout

Grid tracks

- Define rows and columns on grid with the ***grid-template-columns*** and ***grid-template-rows*** properties.
- Define grid tracks.
- A grid track is the space between any two lines on the grid.

```
<div class="wrapper">
  <div>One</div>
  <div>Two</div>
  <div>Three</div>
  <div>Four</div>
  <div>Five</div>
</div>

.wrapper {
  display: grid;
  grid-template-columns: 200px 200px 200px;
}
```



Liquid layouts

- `fr` represents a fraction of available space fo grid container.
- Can mix absolute and flexible, where flexible occupies any remaining space after flexible is subtracted

```
<div class="wrapper">
  <div>One</div>
  <div>Two</div>
  <div>Three</div>
  <div>Four</div>
  <div>Five</div>
</div>


.wrapper {
  display: grid;
  grid-template-columns: repeat(3, 1fr);
}
```

```
.wrapper {
  display: grid;
  grid-template-columns: 500px 1fr 2fr;
}
```

Liquid layouts

- `fr` represents a fraction of available space fo grid container.
- Can mix absolute and flexible, where flexible occupies any remaining space after flexible is subtracted

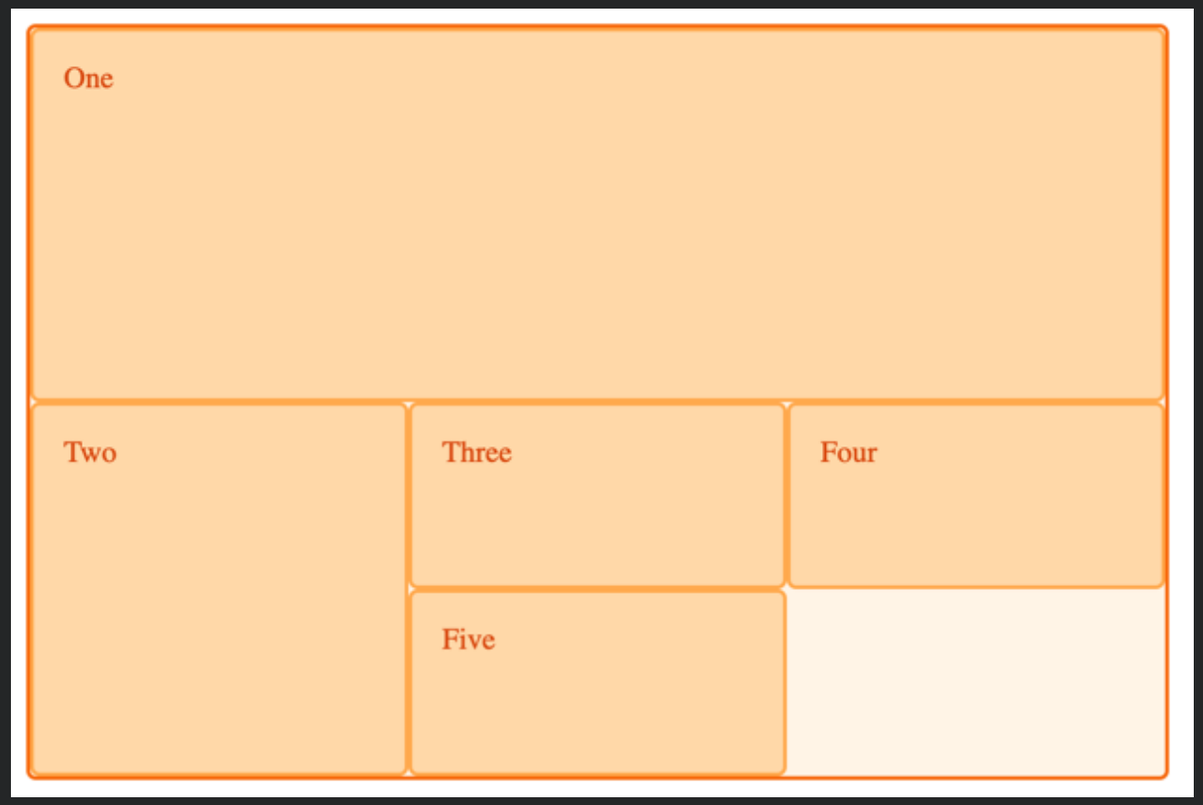
```
<div class="wrapper">
  <div>One</div>
  <div>Two</div>
  <div>Three</div>
  <div>Four</div>
  <div>Five</div>
</div>


.wrapper {
  display: grid;
  grid-template-columns: 1fr 1fr 1fr;
}
```

```
.wrapper {
  display: grid;
  grid-template-columns: 500px 1fr 2fr;
}
```

Positioning items

- Can explicitly place elements inside grid into grid areas

```
<div class="wrapper">
  <div class="box1">One</div>
  <div class="box2">Two</div>
  <div class="box3">Three</div>
  <div class="box4">Four</div>
  <div class="box5">Five</div>
</div>
.wrapper {
  display: grid;
  grid-template-columns: repeat(3, 1fr);
  grid-auto-rows: 100px;
}
.box1 {
  grid-column-start: 1;
  grid-column-end: 4;
  grid-row-start: 1;
  grid-row-end: 3;
}
.box2 {
  grid-column-start: 1;
  grid-row-start: 3;
  grid-row-end: 5;
}
```



Gaps

- Can set gaps between columns and rows

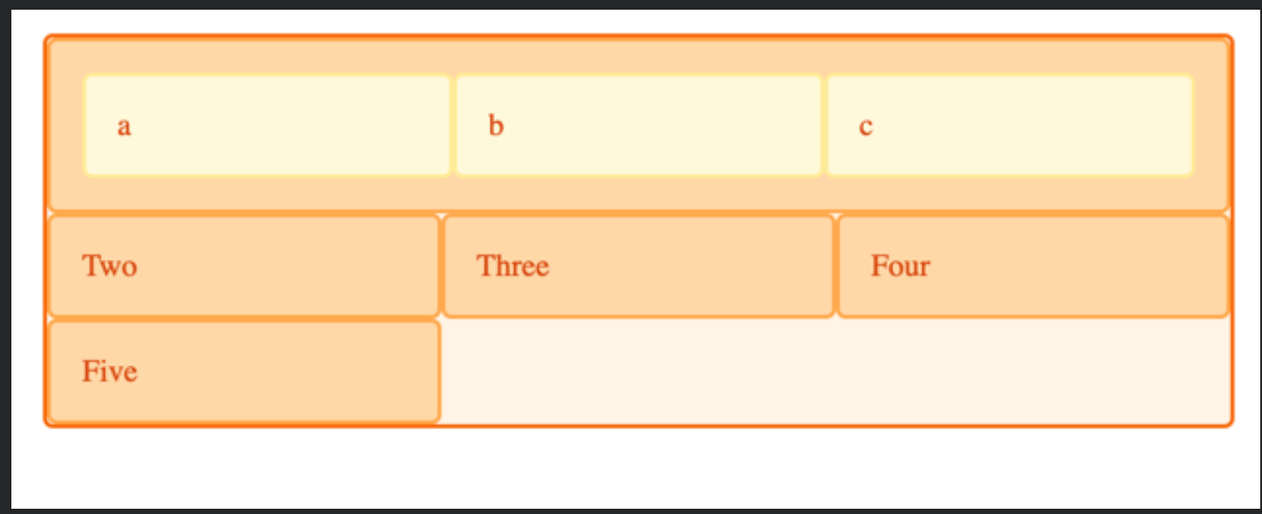
```html
<div class="wrapper">
  <div>One</div>
  <div>Two</div>
  <div>Three</div>
  <div>Four</div>
  <div>Five</div>
</div>
```

```css
.wrapper {
  display: grid;
  grid-template-columns: repeat(3, 1fr);
  column-gap: 10px;
  row-gap: 1em;
}
```

Nesting

- Can nest grids, which behave just like top-level

```
<div class="wrapper">
  <div class="box box1">
    <div class="nested">a</div>
    <div class="nested">b</div>
    <div class="nested">c</div>
  </div>
  <div class="box box2">Two</div>
  <div class="box box3">Three</div>
  <div class="box box4">Four</div>
  <div class="box box5">Five</div>
</div>


.box1 {
  grid-column-start: 1;
  grid-column-end: 4;
  grid-row-start: 1;
  grid-row-end: 3;
  display: grid;
  grid-template-columns: repeat(3, 1fr);
}
```



CSS Exercise

- https://replit.com/@kmoran/swe-432-react-example#src/App.jsx

- Center a component inside it's container
- Use a display grid to create layout with multiple rows and columns
- Override one of the Bootstrap selectors

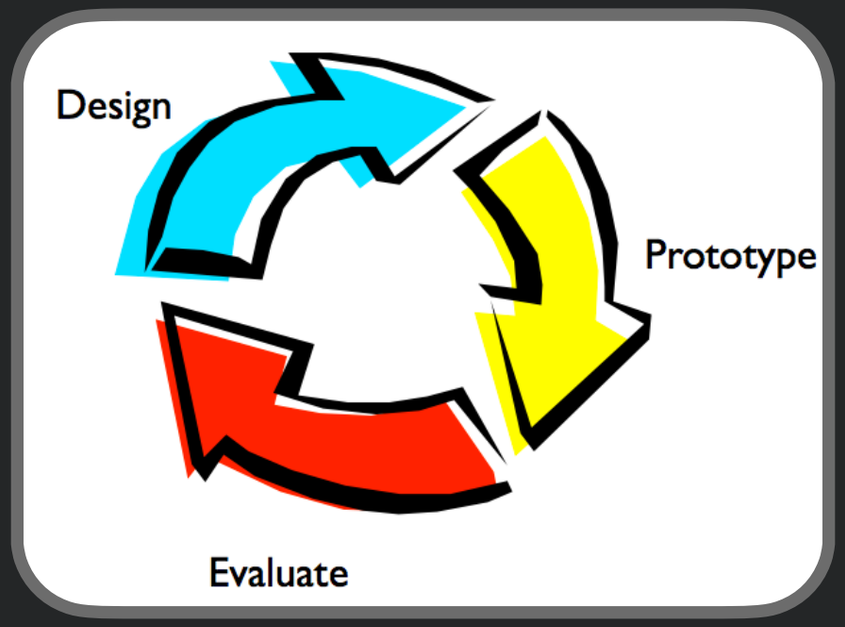
Week 11 - User Centered Design & Sketching + Prototyping

Usability

- A property of the relationship between
  - humans with goal-driven tasks
    - an artifact
- The speed and success with which the goals can be accomplished (task ***performance***)

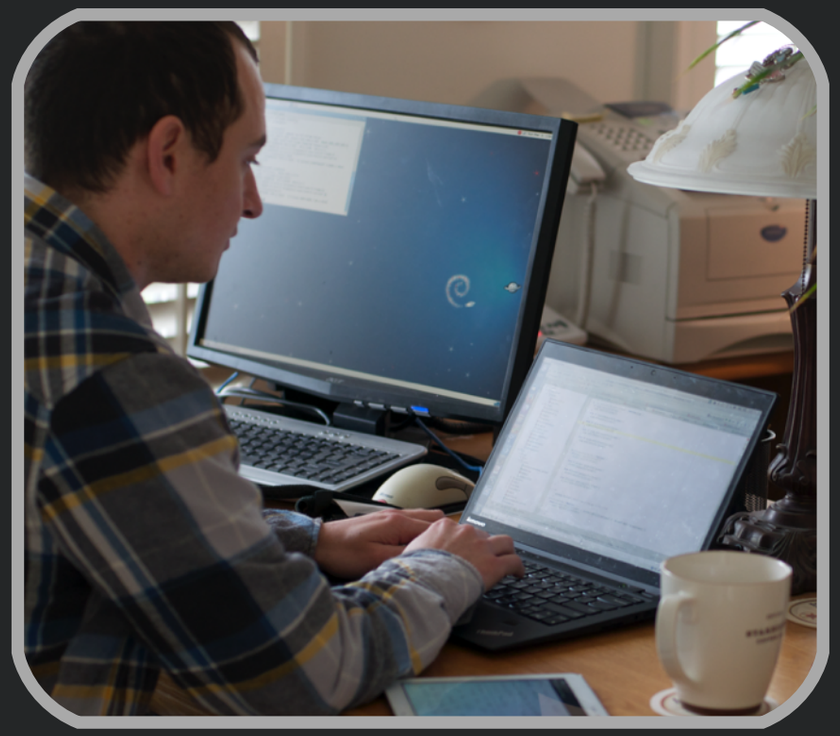
Iterative User-Centered Design

- Given humans with goals and tasks, ***re***design an ***existing*** artifact that helps to accomplish these tasks ***faster*** and more ***successfully***



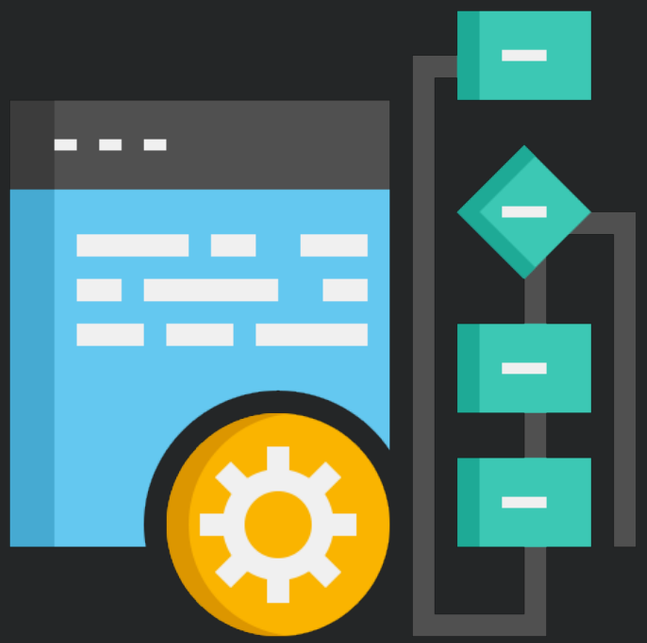
Empirical: Usability **Study**

- Given humans with goals and tasks an artifact, ***observe humans*** to identify usability issues that decrease task performance



- ***"Ground Truth"***

Analytical: Usability **Principles**



- Given humans with goals and tasks and an artifact, ***<u>assess for conformance to UI principles</u>*** to identify usability issues that decrease task performance

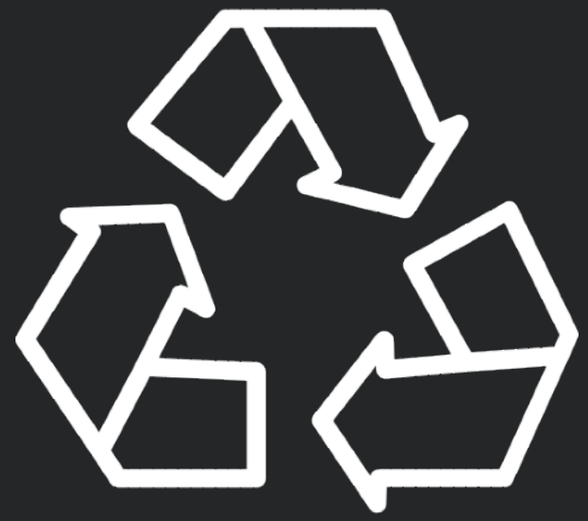
- ***Approximation of "ground truth"***

Iterative Model of User-Centered Design

Observation

(Re)Define the Problem

Understand User Needs



Idea Generation

Brainstorm
what to build

Prototype/ Implementation

Build

Test

Evaluate what
you have built

Heuristic Evaluation (Analytical)

- "***Discount*** usability engineering methods" - Jakob Nielsen

- Involves a small team of evaluators to evaluate an interface based on recognized usability principles

- Heuristics – "rules of thumb"

Adapted from slides by Bonnie John and Jennifer Mankoff

Heuristic Evaluation

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition vs. recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

Advantages of Heuristic Evaluation

- "Discount usability engineering" - Intimidation low
- Don't need to identify tasks, activities
- Can identify some fairly obvious fixes
- Can expose problems user testing doesn't expose
- Provides a language for justifying usability recommendations

Disadvantages of Heuristic Evaluation

- Un-validated
- Do not employ real users
- Can be error prone
- Better to use usability experts
- Problems unconnected with tasks
- Heuristics may be hard to apply to new technology

Using Heuristic Evaluation

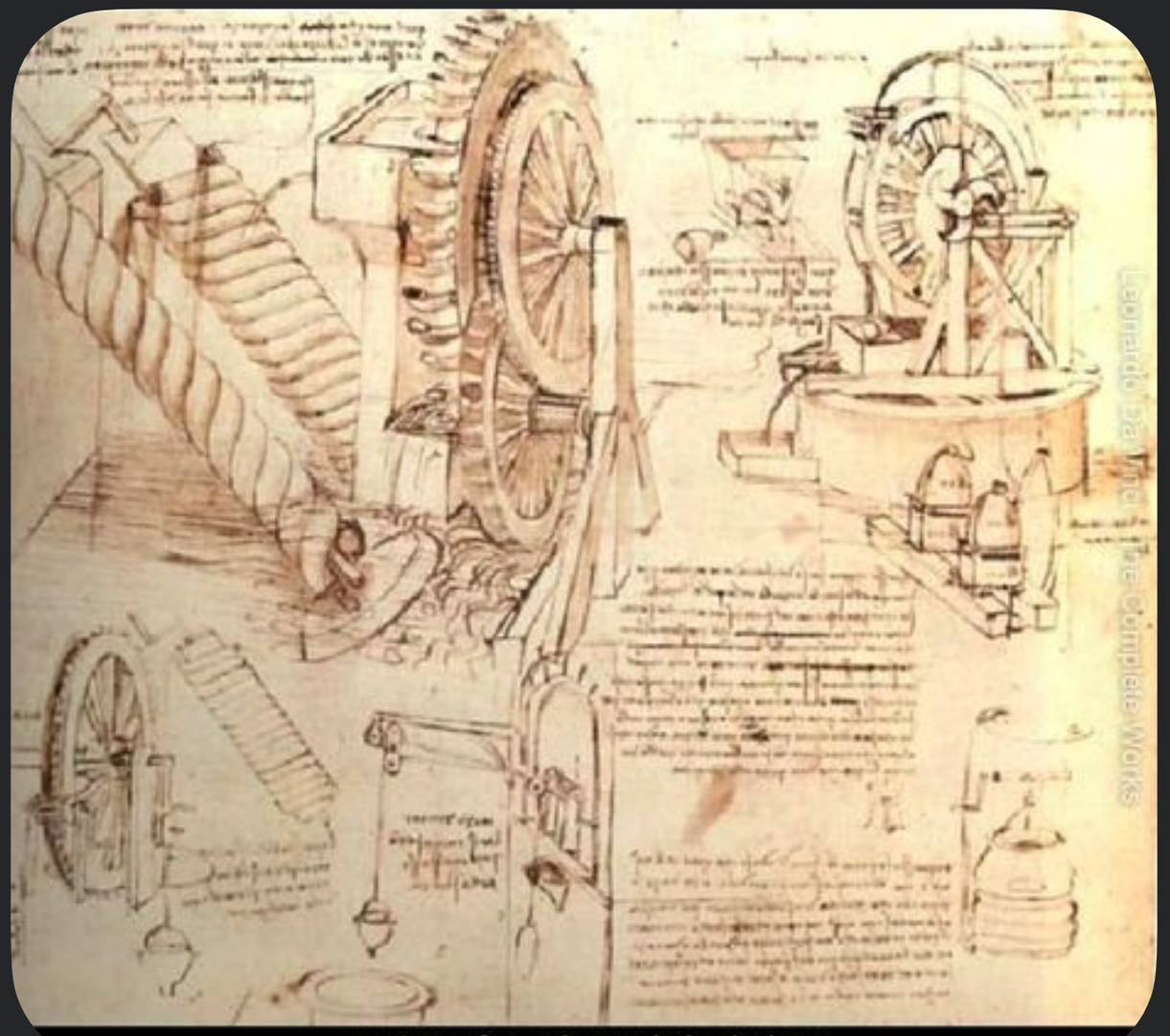
- Can be used informally to identify issues in a website
- Can be used as a more formal usability inspection method
- Evaluators each first separately identify issues
- Issues then combined from each evaluator

Ways to Use Heuristic Evaluation

- Early in design process to catch major issues
- When time or resources are not available for empirical usability evaluation

Why Sketch?

- Sketching offers ***visual*** medium for exploration, offering cognitive scaffolding to externalize cognition

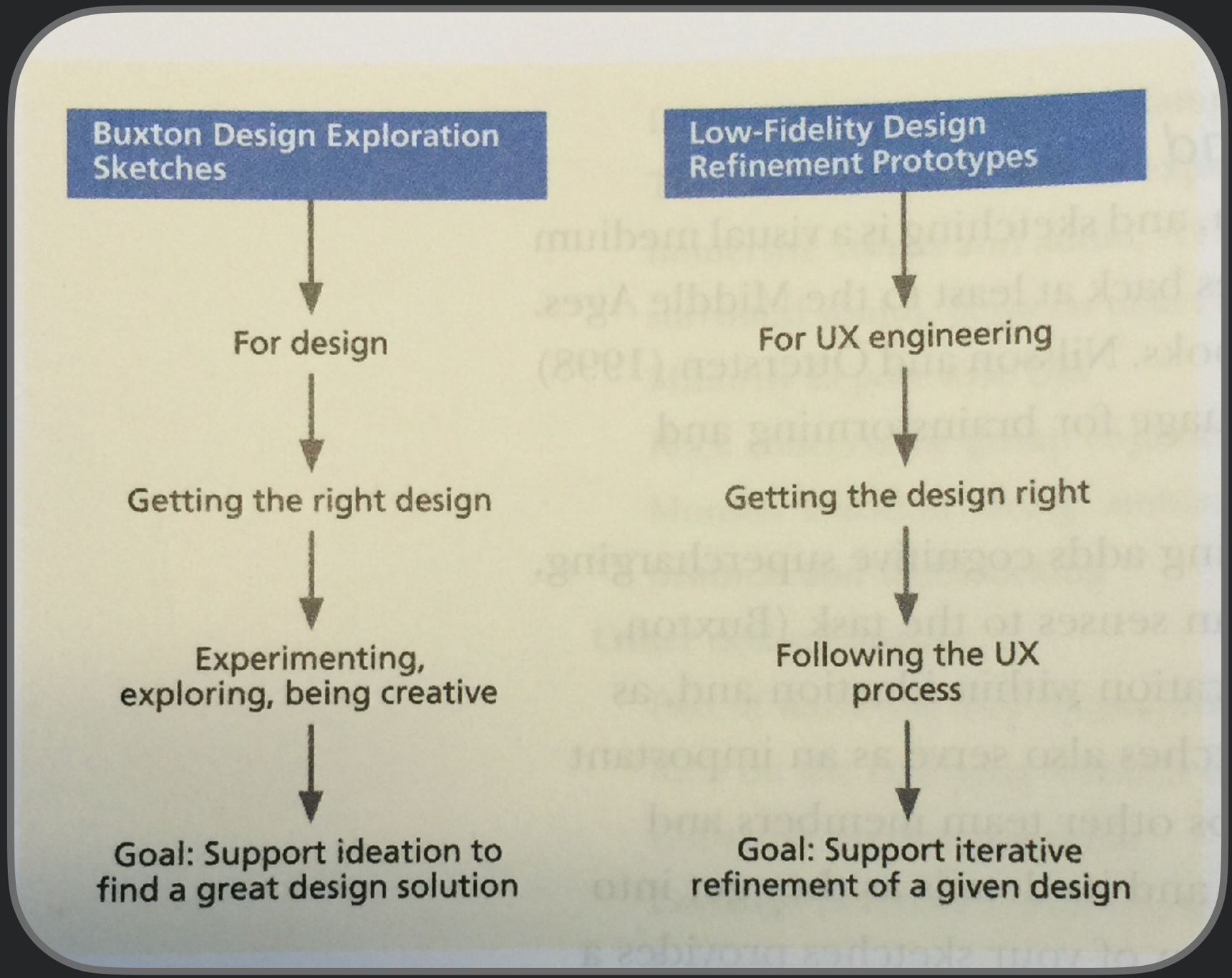


courtesy of www.leonardoda-vinci.org

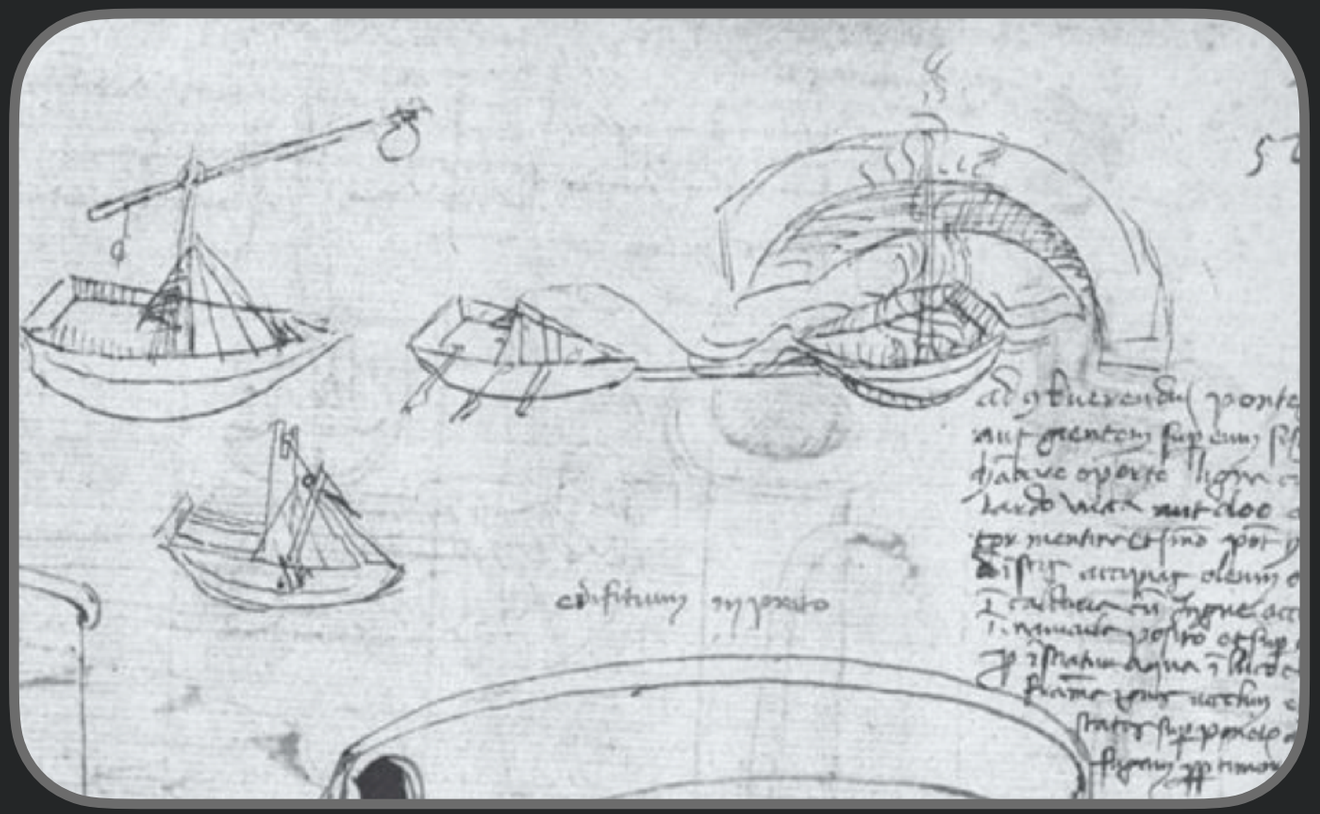
Being Creative with Sketches

- How do you come up with a great idea?
  - Generate lots of ideas
  - Work through ideas through externalization in sketch
  - Critique the ideas
  - Refine them to make them better
- Sketching offers a low-cost medium for working with early ideas ***before*** committing to one
- Design is process of creation & ***exploration***

Sketching vs. Prototyping

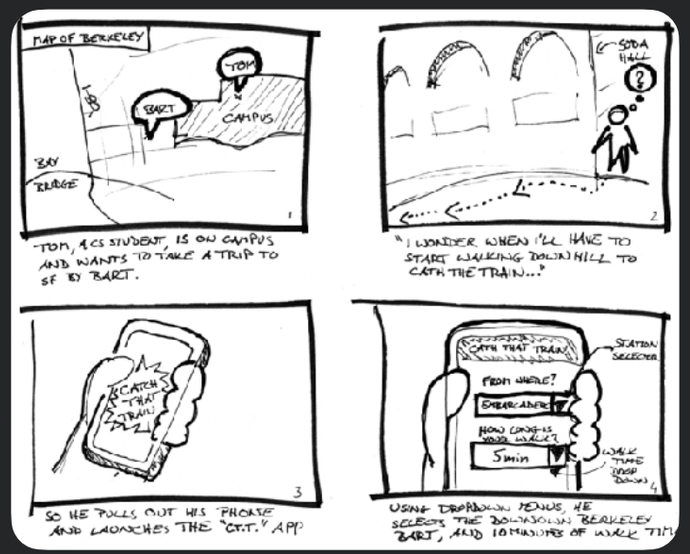


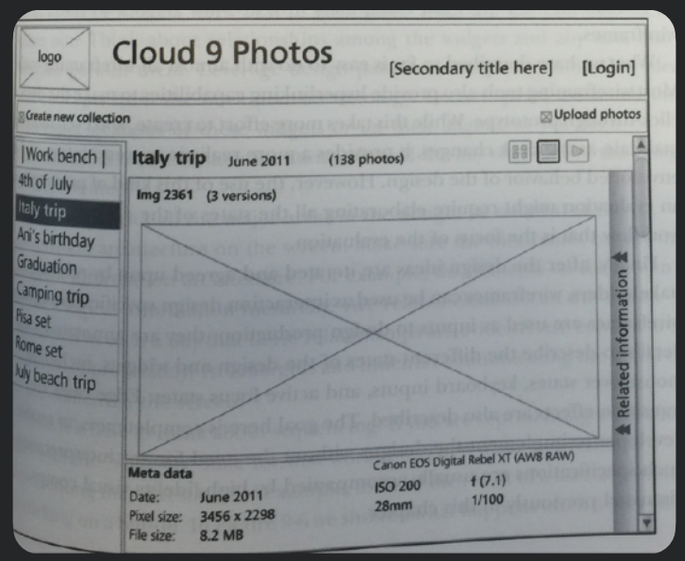
Sketches are Sketchy

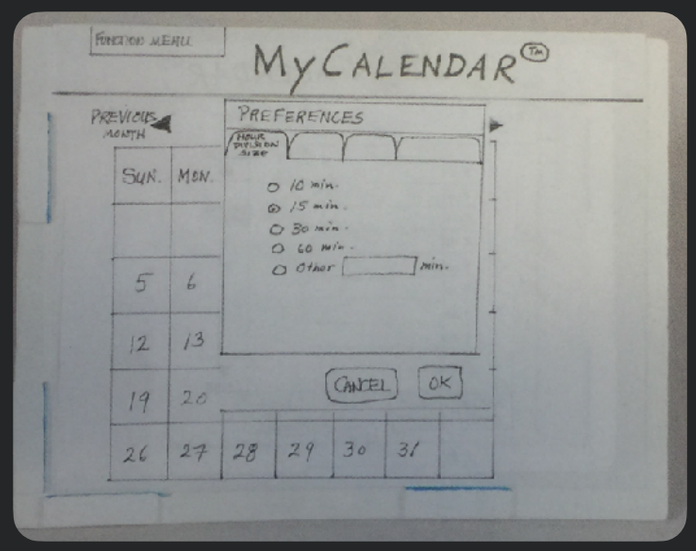


- Not mechanically correct and perfectly straight lines
- ***Freehand***, open gestures
- Strokes may miss connections
- Resolution & detail **low** enough to suggest is concept
- Deliberately ***ambiguous*** & abstract, leaving “holes” for imagination

Fidelity of Sketches & Mockups







Storyboard — Wireframe — Prototype

low ← → high

Fidelity

(many details left unspecified)

(more polished & detailed)

Storyboards for UI Design

- Sequence of visual “frames” illustrating ***interplay*** between user & envisioned system
- Explains how app fits into a larger ***context*** through a single scenario / story
- Bring design to ***life*** in graphical clips - freeze frame sketches of user interactions
- “Comic-book” style ***illustration*** of a scenario, with actors, screens, interaction, & dialog

Crafting a Storyboard

- Set the stage:
  - Who? What Where? Why? When?
- Show key interactions with application
- Show consequences of taking actions
- May also think about errors

Example Elements of a UI Storyboard

- Hand-sketched pictures annotated with a few words
- Sketch of user activity before or after interacting w/ system
- Sketches of devices & screens
- Connections with system (e.g., database connection)
- Physical user actions
- Cognitive user action in “thought balloons”

Frame Transitions

- Transitions between frames particularly important
- What users think, how users choose actions
- Many problems can occur here (e.g., gulfs of execution & evaluation) - we will talk more in a future class!
- Useful to think about how these work, can add thought bubbles to describe

Wireframes

- Lines & outlines (“wireframes”) of boxes & other shapes
- Capturing emerging interaction designs
- Schematic designs to define screen content & visual flow
- Illustrate approximate visual layout, behavior, transitions emerging from task flows
- Deliberate unfinished: do not contain finished graphics, colors, or fonts

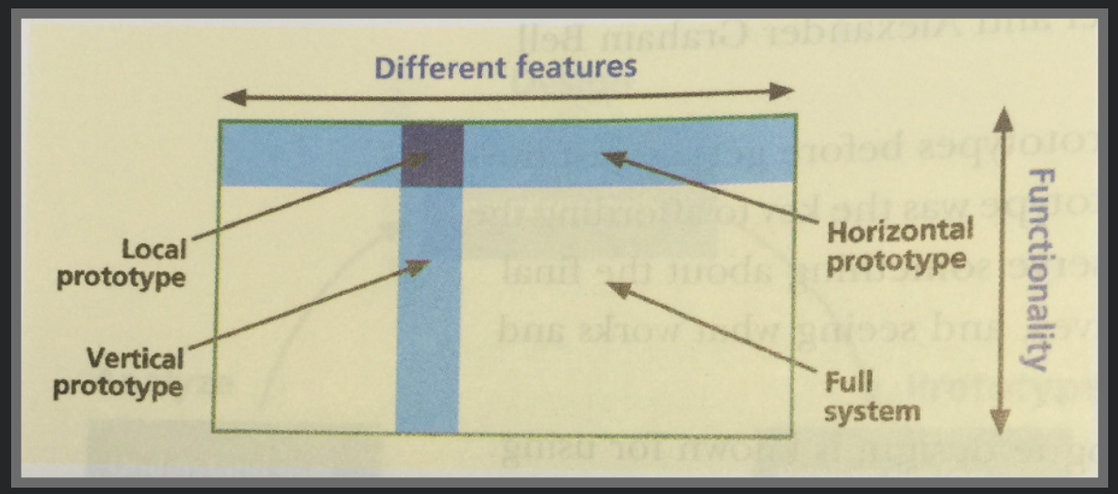
Wireframes

- Can be used to step through a particular scenario
- Focus on key screens rather than every screen
- Tools can help
  - Can be made clickable
  - Can use stencils & templates; copy & edit similar screens

Prototyping

- How do you know your system design is right before you invest the time to build it?
- Answer: prototyping!
  - Evaluation performed ***before*** investing resources in building finished product
  - Early version of system constructed much ***faster*** & with less expense used to evaluate & ***refine*** design ideas

Types of Prototypes



- Which details do you leave out?
- **Horizontal**: ***broad*** in features, less depth
  - Explore overall concept of app, but not specific workflows
- **Vertical**: lots of ***depth***, but only for a few features
  - Enables testing limited range of features w/ realistic user evals
- **T**: most of UI realized at low depth, few parts realized in depth
  - Combination of vertical & horizontal
- **Local**: focused prototype on ***specific*** interaction detail

Interactivity of Prototypes

- Scripted, click through prototypes
  - Prototype w/ ***clickable*** links to move between screens
  - Live action storyboard of screens
    - Simulates real ***task flow***, but w/ static content
- Fully-implemented prototypes
  - Usually ***expensive*** to implement actual system
  - But can build key piece of system first to evaluate

Week 12: Think-aloud Usability Studies and Site Design

Why Conduct Usability Studies?

- Evaluate interaction design with ***real*** empirical data, gathering ground truth of user performance
- Identify ***usability issues***

Think-aloud Usability Study

- Goal: observe users using app, identify usability issues
- Can use with
  - paper prototype
  - HTML prototype
  - Wizard of Oz study
  - actual app

Steps in a Usability Evaluation Study

- Formulate ***goals*** of study
- Design study protocol, tasks, materials, data collection, …
  - Pilot study design
- ***Conduct*** study
- ***Analyze*** data to assess task performance and identify usability issues

Informed Consent

- Important for participants to be told up front what they will do and provide affirmative consent
- Helps allay potential participant fears
- Make clear purpose of study
- Make clear that you are evaluating your design, **not** the user

Tasks

- What will users do?
- Goals for task design:
  - Provide specific goal: something that the user should accomplish
  - Comprehensive enough to exercise key features of your app
  - Short enough to minimize participant time commitments

Communicating Tasks

- Provide a scenario explaining the background of what users will be doing
- Provide a specific goal that the user should accomplish
  - But ***not*** how they should accomplish it
  - Don’t give away how you hope users will accomplish goal
- Communicate ***end criterion*** for task - how do they know they’re done?
- Provide maximum time limit after which they will be stopped

Training

- Goal: ***avoid*** unless really necessary
- Training necessary when
  - Participants require specialized knowledge to act as target users
  - Target users will have access to specialized training materials before they begin study

Interactions During the Task

- Goal: listen, not talk
- Prompt participants to think aloud when necessary
  - e.g., What are you trying to do? What did you expect to happen?
- If show signs of stress / fatigue, let them take a break
- Keep participants at ease
  - If participants frustrated, reassure & calm participants
  - If so frustrated they want to quit, let them

Giving Help

- If participants totally off track, small reminder of goal might help
- Should ***not*** give participants information about how to complete the task
- What if user asks for help?
  - Direct them to think through it or work it out for themselves

Collecting Critical Incidents

- *Any action that does not lead to progress in performing the desired task*
- Often related to a gulf of execution or gulf of evaluation
- Generally does not include
  - accessing help
  - random acts of curiosity or exploration

Understanding a Critical Incident

- Important to understand in the moment what users goal is and what actions they are taking
- When a critical incident occurs, jot down
  - The time
  - What user was trying to do
  - What user did

Reporting a Critical Incident

- Problem statement: summary of problem and effect on user (but not a solution!)
- User goals: what was user trying to do?
- Immediate intention: at the moment in time when problem occurred, what was the user trying to do
- Possible causes: speculate on what might have led user to take action they did

Critical Incidents → Usability Issues

- Group together similar incidents to form ***usability issue***
  - Match similar critical incidents within and across study sessions
  - Identify underlying cause
- Brainstorm potential fixes

Challenges in Site Design

- Sometimes large space for users to navigate to find information.
- No spatial sense of scale. 50 pages? 500 pages? 50,000 pages?
- No sense of direction. Which way did I just go?
- No sense of location. No spatial anchoring of where I am now and how that relates to where I could go.
- No place to check if something is *not* present or supported.

Site Design

- Some key design dimensions
  - Organization of content into pages / screens
  - Organization of content within pages / screens
  - Ways in which users navigate between pages / screens
- Key design goals
  - Reduce the time / cost for users to reach content
  - Reduce the irrelevant information users must read

Planning

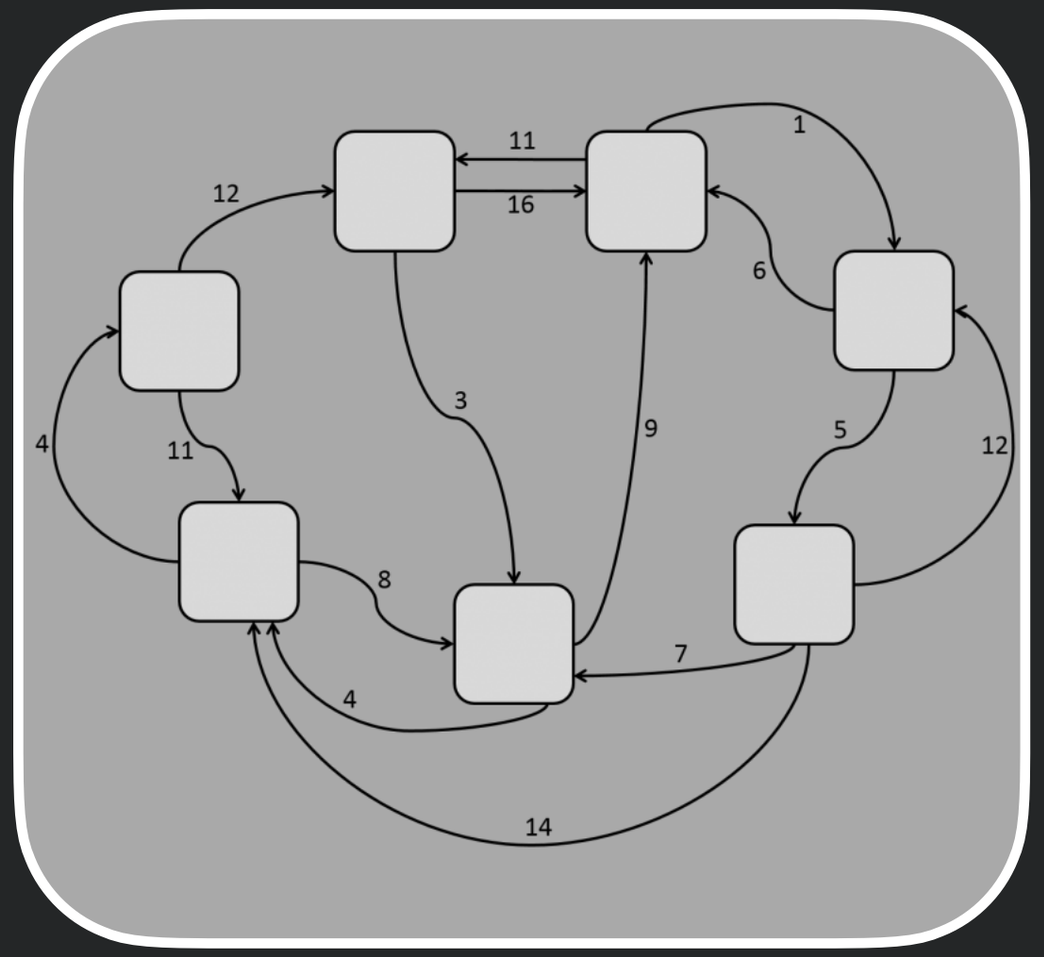
- Help users determine what they **can** do
  - Is this the right site for my goals? Is this the right page where I should spend my time?
- Support users in how they **determine** what to do
  - If this is the right place, how do I reach goal?

Information Foraging

- Mathematical model describing navigation
- Analogy: animals foraging for food
  - Can forage in different patches (locations)
  - Goal is to maximize chances of finding **prey** while minimizing time spent in hunt
- Information foraging: navigating through an information space (patches) in order to maximize chances of finding prey (information) in minimal time

Information environment

- Information environment represented as ***topology***
  - Information ***patches*** connected by traversable ***links***
- Examples
  - Web pages, connected by links
  - Menu options & dialogs connected by commands
  - Locations on map, connected by search, scroll, move interactions with map



Traversing Links

- Patch - a space in the environment where a user is located (e.g., a page, a dialog)
- Links - connection between patch offered by the information environment
- Cues - information features associated with outgoing links from patch
  - E.g., text label on a hyperlink
- User must choose which, of all possible links to traverse, has best chance of reaching prey

Scent

- User interprets cues on links by likelihood they will reach prey
- e.g., do I think that the “Advanced options" page is likely to have the option I’m looking for?

Design Implications of Information Foraging Theory

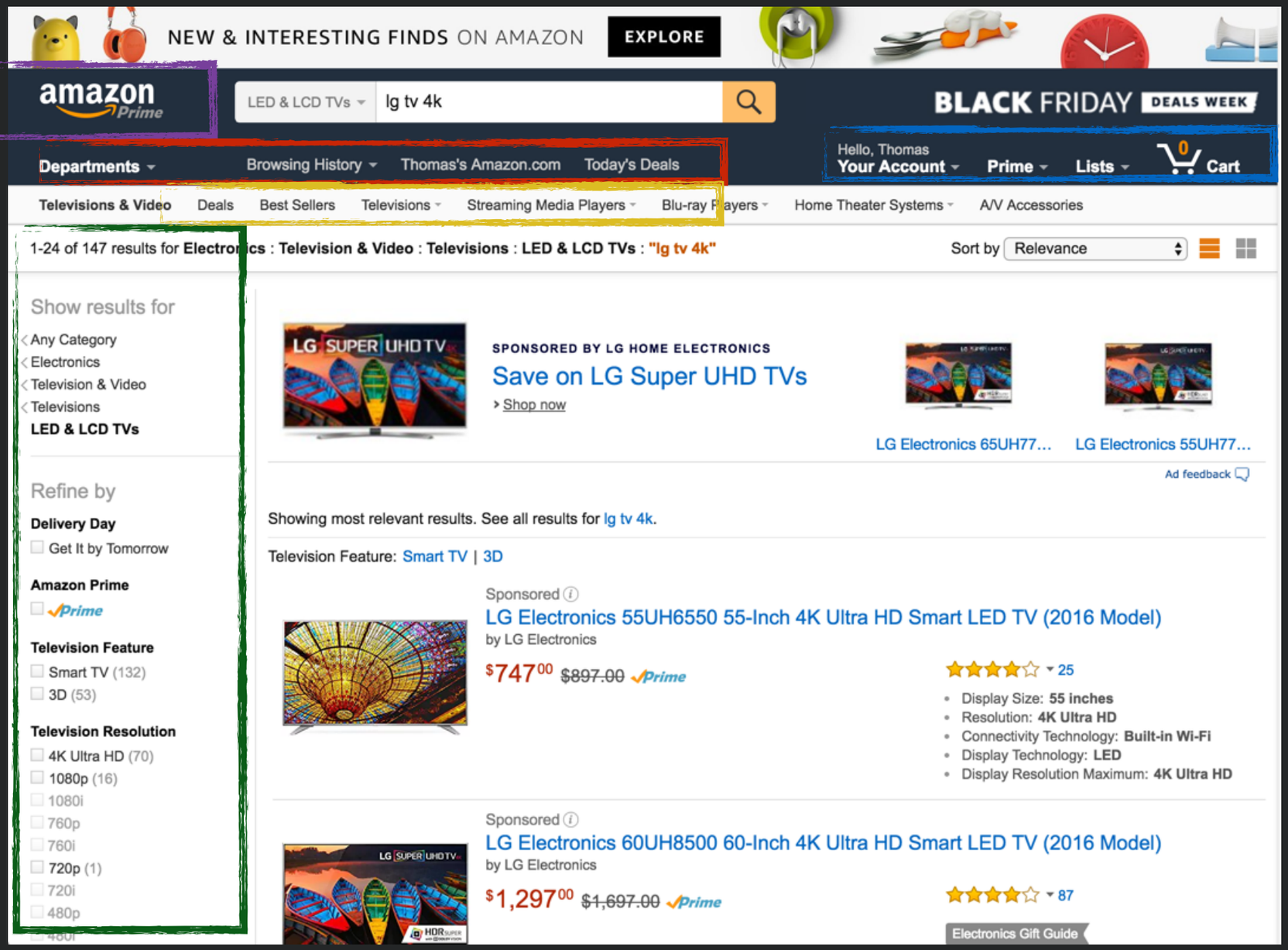
- Organize information into functionally ***related*** groups
  - If information required is already on same page, no need to go elsewhere
- Design effective ***cues***, helping users predict what will be found by traversing links
  - Better cues --> better ability to navigate to correct pages
- Match ***expectations*** of user's mental model
  - Cues are interpreted relative to mental model
- Provide ***search***
  - In large spaces, faster to search than traverse links

Web navigation conventions

Site ID

You are here

Local navigation

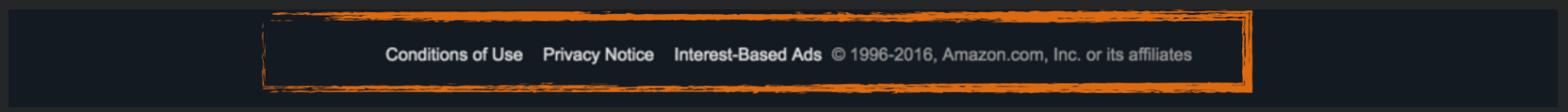


Utilities

Sections

...

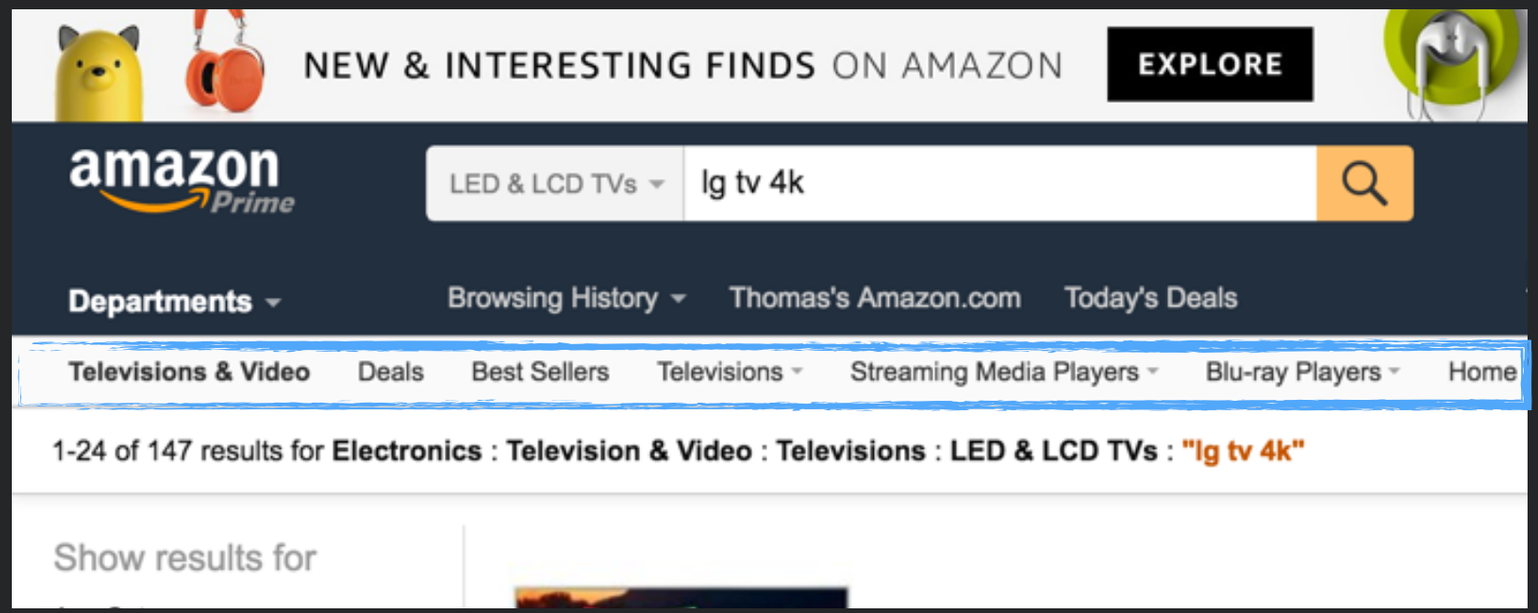
Footer navigation



Persistent Navigation

- Forms a common idiom users already understand
- Gives instant confirmation that still on the same site
- Supports consistency and standards
  - If *all* of your pages function same way, users know how to do actions & what to expect
  - Ok for specialized page like forms that are clearly different to not follow conventions.

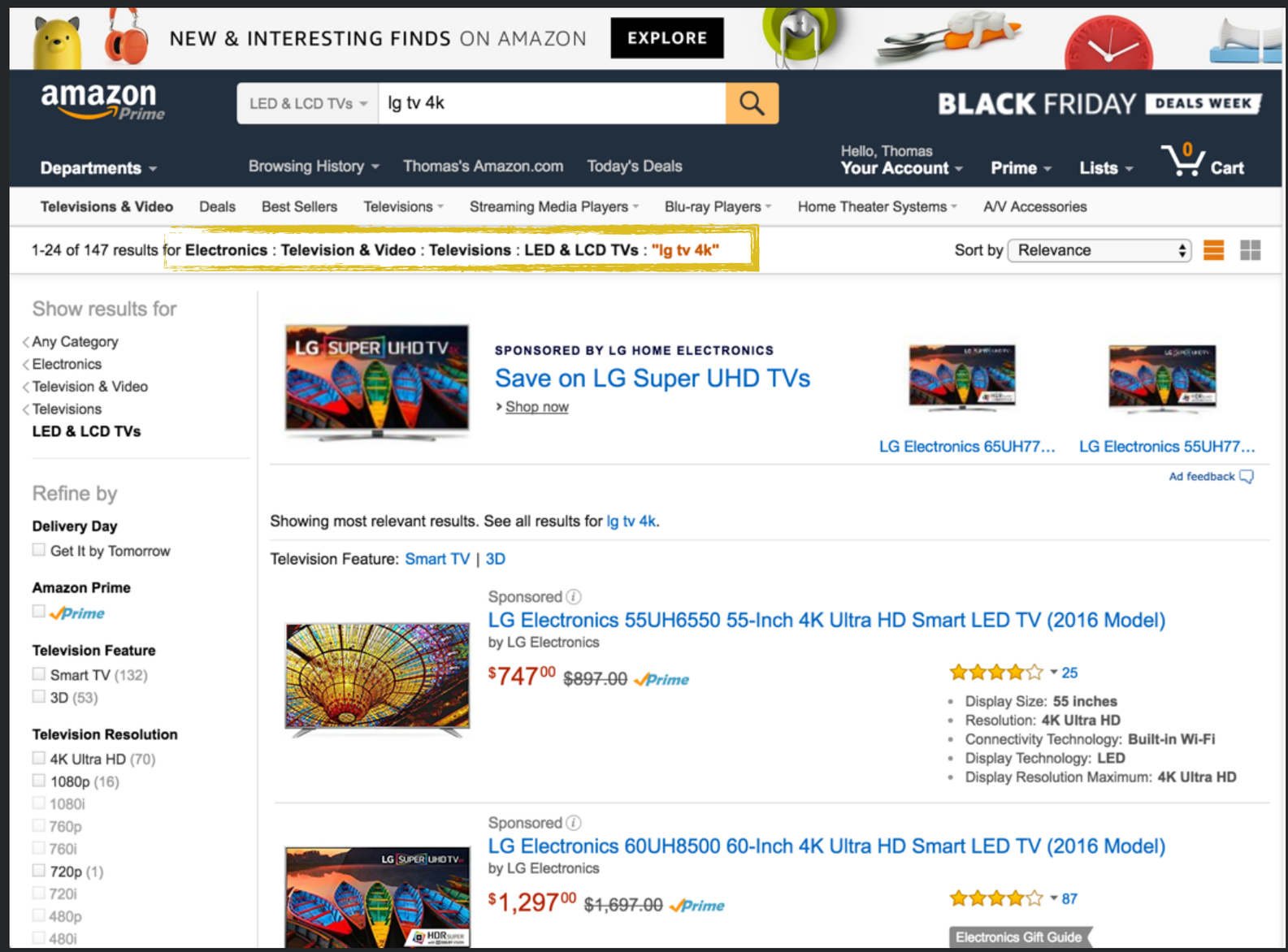
Tabs



- Example of a metaphor: tab dividers in a three ring binder or folders in a file drawer
- Partition into sections
- Advantages
  - Easily understood and self-evident
  - (Usually) hard to miss

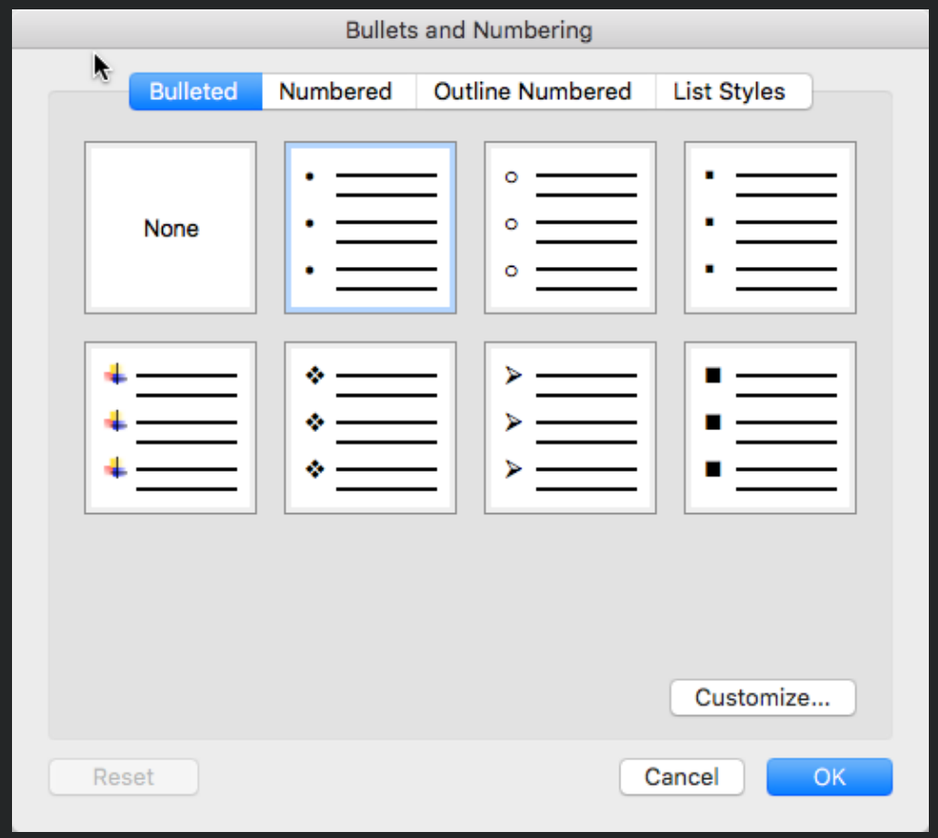
Breadcrumbs

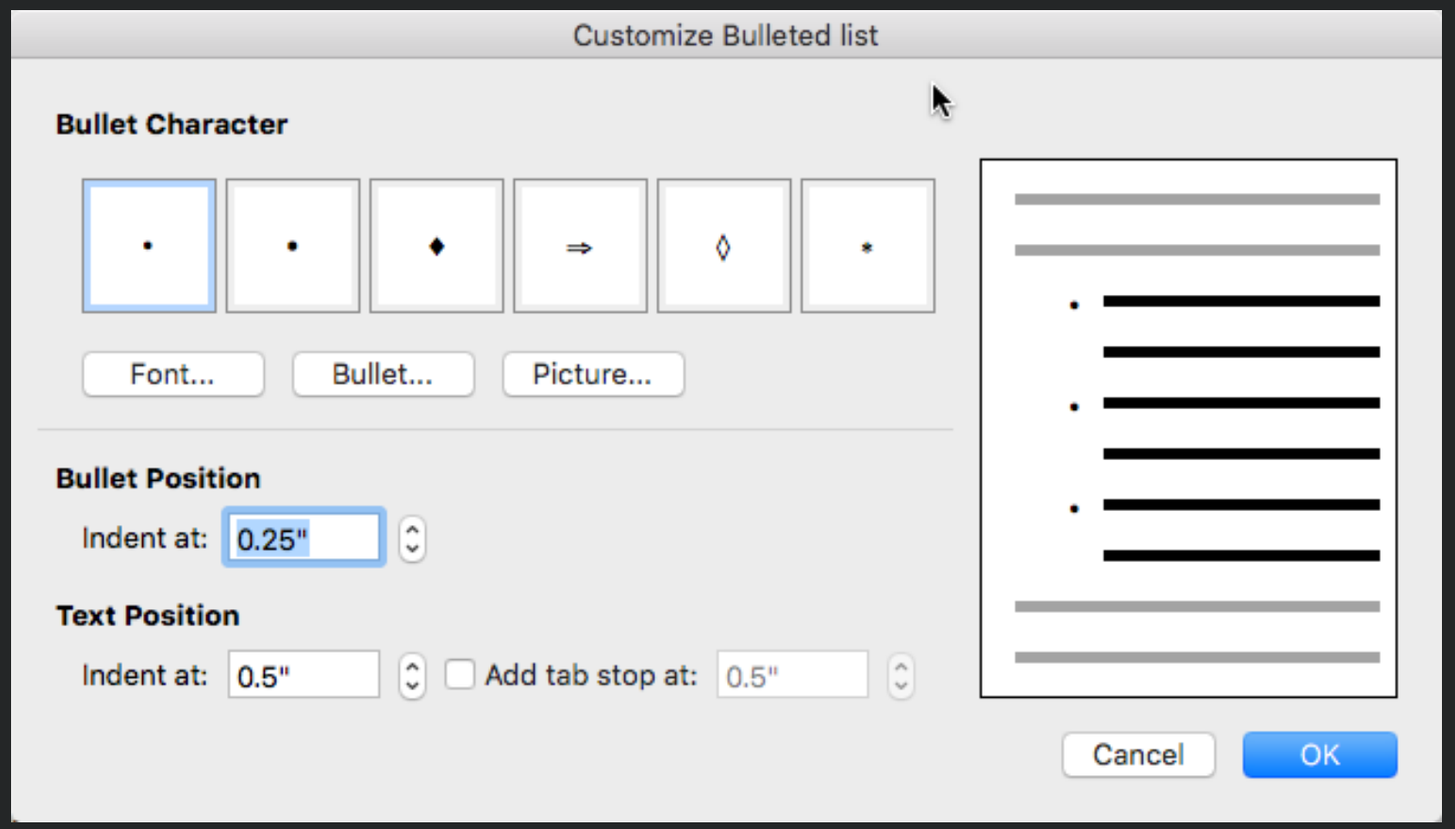
- Offer trail of where the user has been and how they got there
- Shows hierarchy of information space
- Shows current location



Progressive Disclosure

- a.k.a. details on demand
- Separate information & commands into layers
- Present most frequently used information & commands first





Effective Site Design

- Answers to the following should be obvious for a good site design
  - What site is this? (Site ID)
  - What page am I on? (Page name)
  - What are the major sections of this site? (Sections)
  - What are my options at this level? (Local navigation)
  - Where am I in the site? (“You are here” indicators)
  - How can I search?

Metaphors - Advantages

- Leverages understanding of familiar objects & their functions
  - File cabinets, desks, telephones
- Provides ***intuitive*** understanding of possible affordances & eases mapping tasks to actions
  - Open a folder, throw file in trash, momentum scrolling

Metaphors - Disadvantages

- Tyranny of metaphor: ties interactions closely to workings of physical world
- Adds useless overhead in extra steps, wastes visual bandwidth
- Taken literally, becomes non-sensical
  - e.g., nesting folders 10 levels deep

Alternative - Idioms

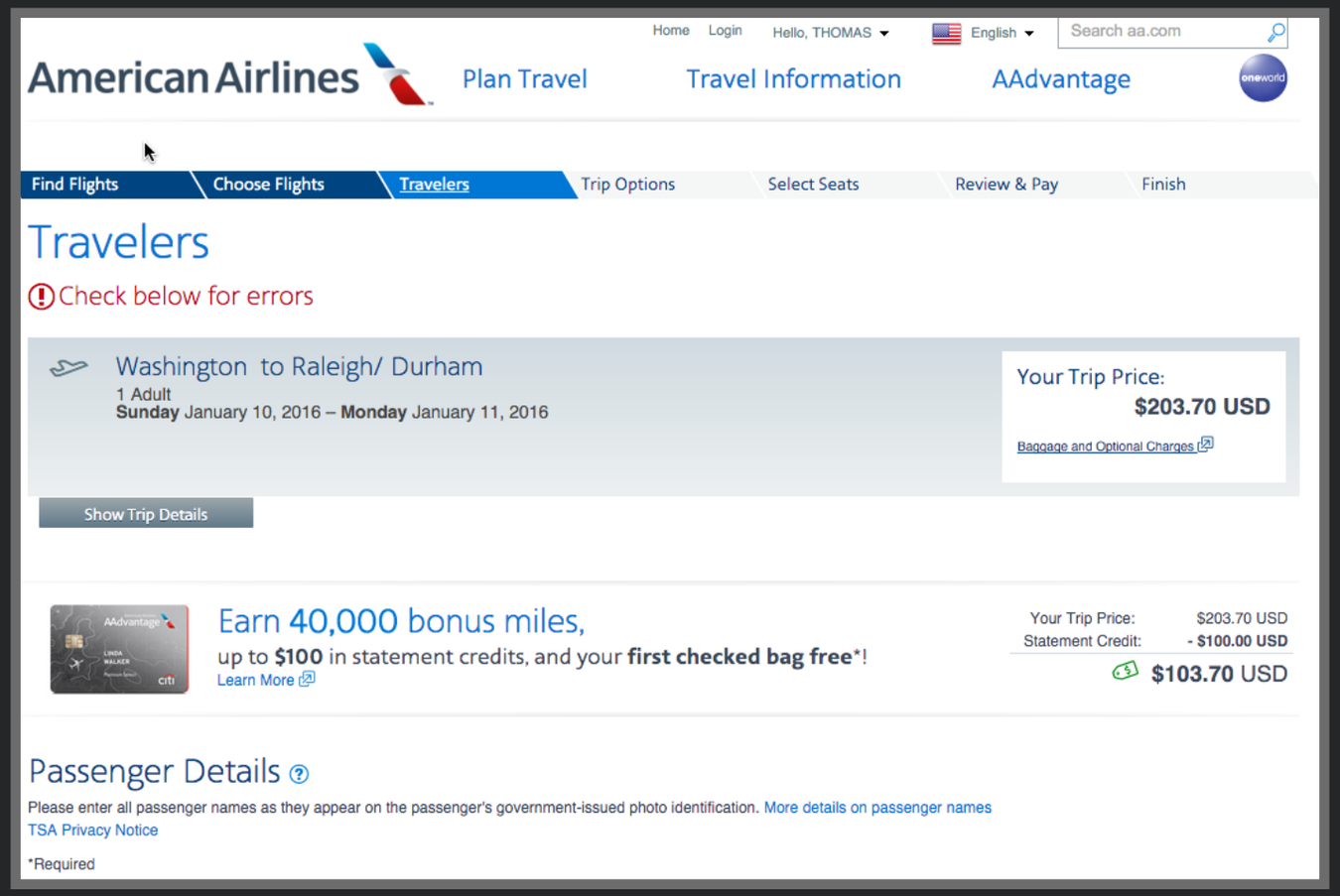
- A consistent mental model of how something works
  - e.g., Files: open / close / save / save as
- Offers intuitive understanding of affordances & interactions
- Provides consistent vocabulary for describing interactions
- Only have to learn it ***once***
- Might have originated in real world, but thought of in terms of mental model for UI interactions

Task Structure

- In some cases, users must take actions in specific sequence
- Must input some information before being able to access subsequent information
  - e.g., must select a shipping method before seeing a final price
- To the extent possible, want to leave users in control of task (user control and freedom)
- But also do not want to distract users by making unrelated decisions in random order (flexibility and efficiency of use)
- And do not want to overwhelm users with too many options at a time (minimalist design)
- Good designs need to balance tradeoffs

Separate long tasks into sequences

- Reduce short term memory demands by having user only work on one aspect of larger task at a time
- Don’t interrupt users in the middle with unrelated tasks
- Provide closure of each subtask at the end

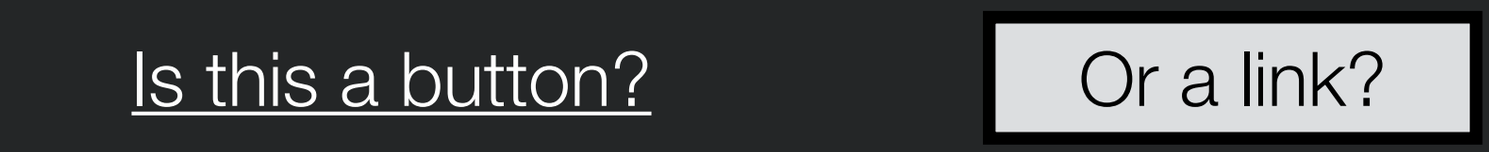


Interaction Flow Guidelines

- Don’t use dialogs to report normal behavior
- Separate commands from configuration
- Don’t ask questions, give users choices
  - Give users default input, show possible options
- Make dangerous choices hard to reach
- Design for the probable, provide for the possible

Week 13: Interaction Techniques & Visual Design

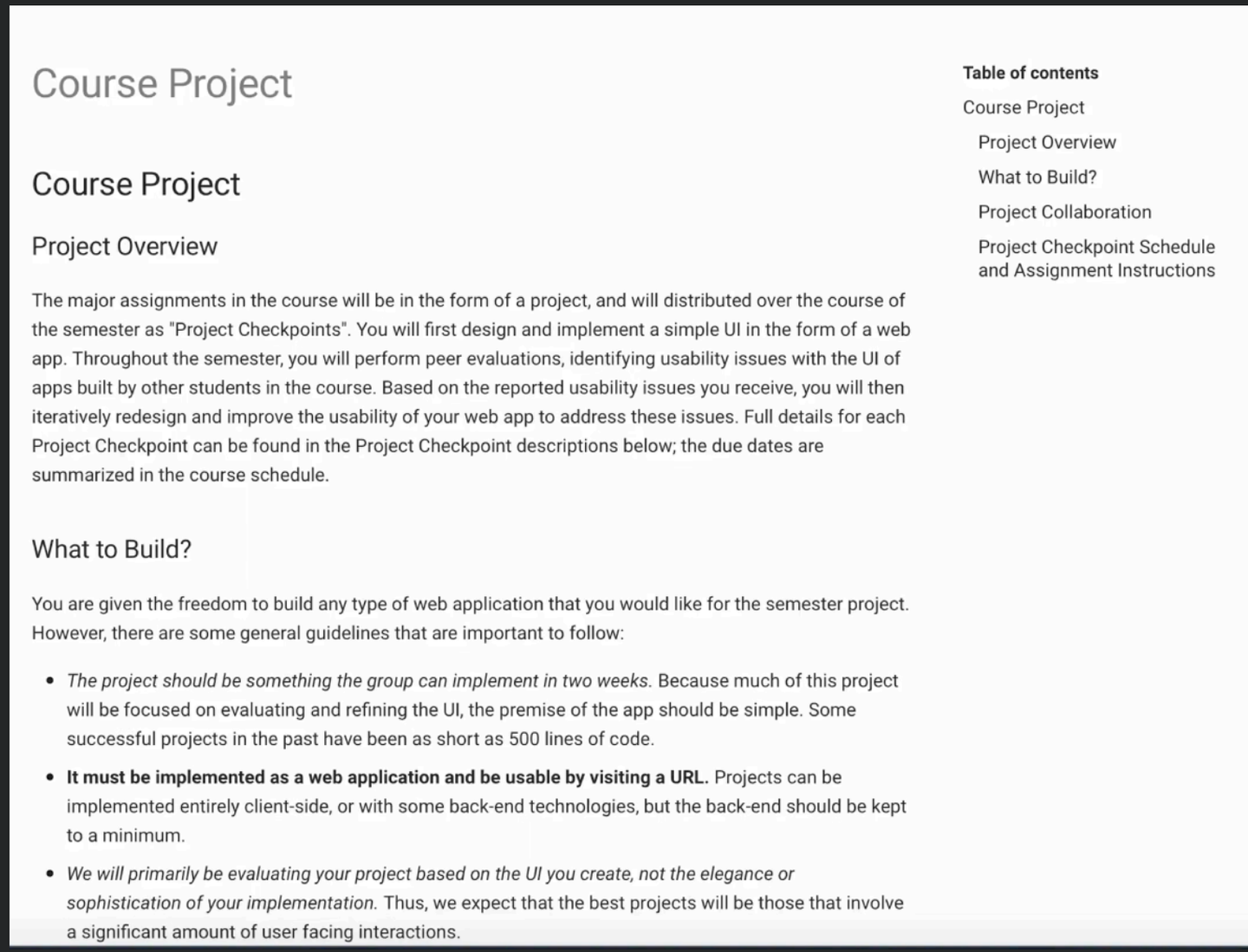
Signifiers



- Goals
  - Show which UI elements can be manipulated
  - Show how they can be manipulated
  - Help users get started
  - Guide data entry
  - Suggest default choices
  - Support error recovery

Hinting

- Indicate which UI elements can be interacted with
- Possible visual indicators
  - ***Static hinting*** - distinctive look & feel
  - ***Dynamic hinting*** - rollover highlights
  - ***Response hinting*** - change visual design with click
  - ***Cursor hinting*** - change cursor display



Clarity of Wording

- Choose words carefully
- Speak the user's language
- Avoid vague, ambiguous terms
- Be as specific as possible
- Clearly represent domain concepts

Likely & Useful Defaults

- Default text, if relevant (e.g., date)
- Default cursor position
- Avoid requirements to retype & re-enter data

Modes

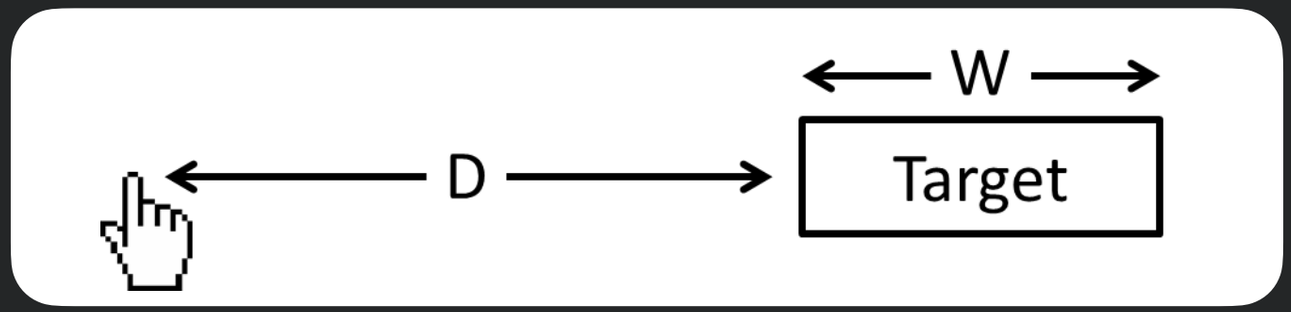
- Vary the effect of a command based on state of system
- Examples
  - caps lock
  - insert / overtype mode
  - vi / emacs command modes
  - keyboard entry used for controlling game and chatting

Challenges with Modes

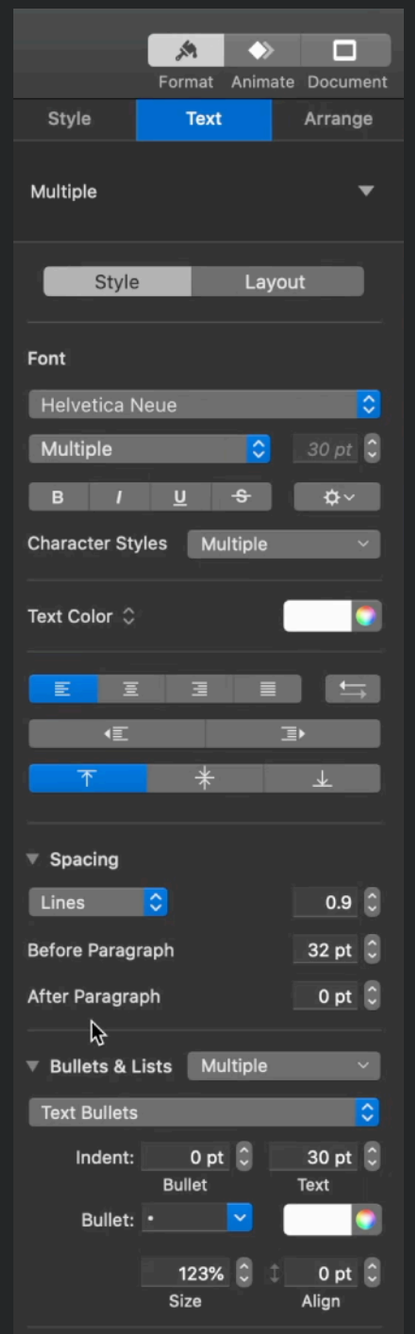
- Modes create inconsistent mapping
  - E.g., control S sometimes saves, sometimes sends email
  - Especially dangerous for frequent interactions that become highly automatic System 1 actions

- Avoid when possible
- Clearly distinguish if necessary
  - Make clear to user which mode they are in and how to change

Fitt's Law

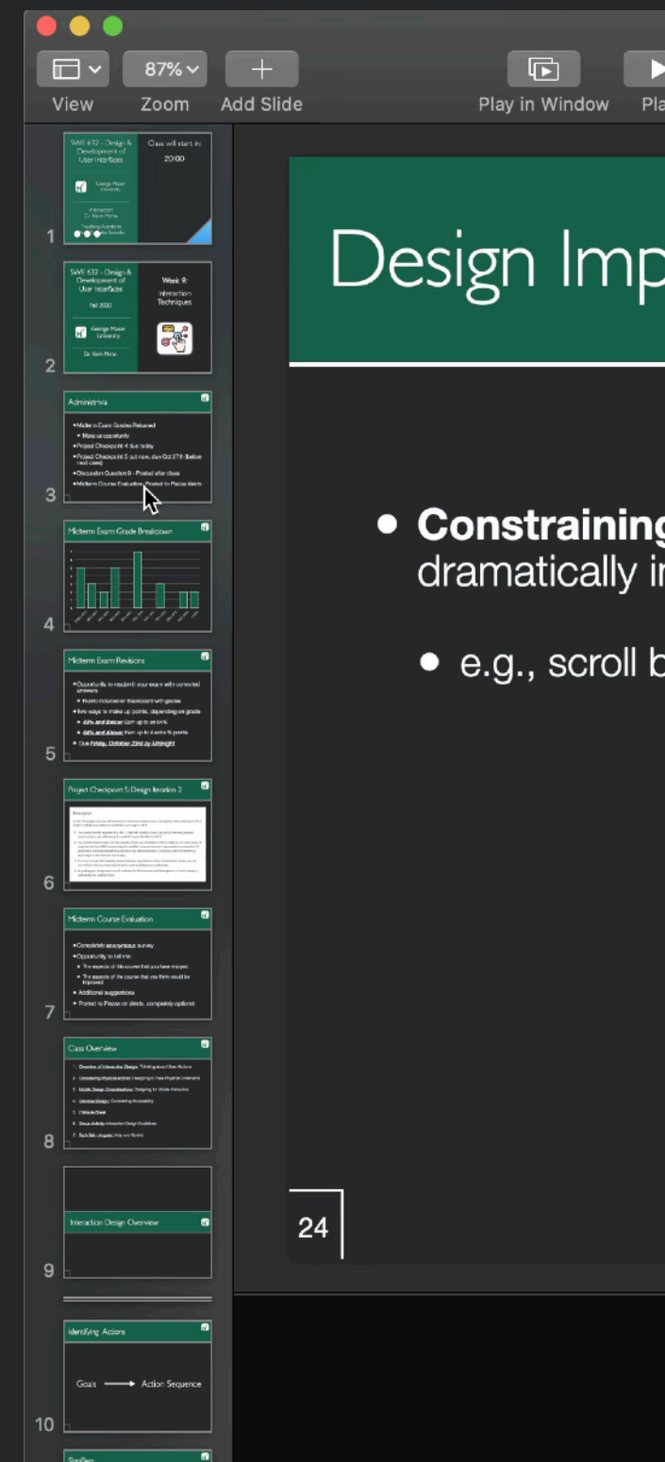


- Time required to move to a target ***decreases*** with target ***size*** & ***increases*** with ***distance*** to the target
- Movements typical consist of
  - one large quick movement to target (***ballistic*** movement)
  - fine-adjustment movement (***homing*** movements)
- Homing movements generally responsible for most of movement time & errors
- Applies to rapid pointing movements, not slow continuous movements



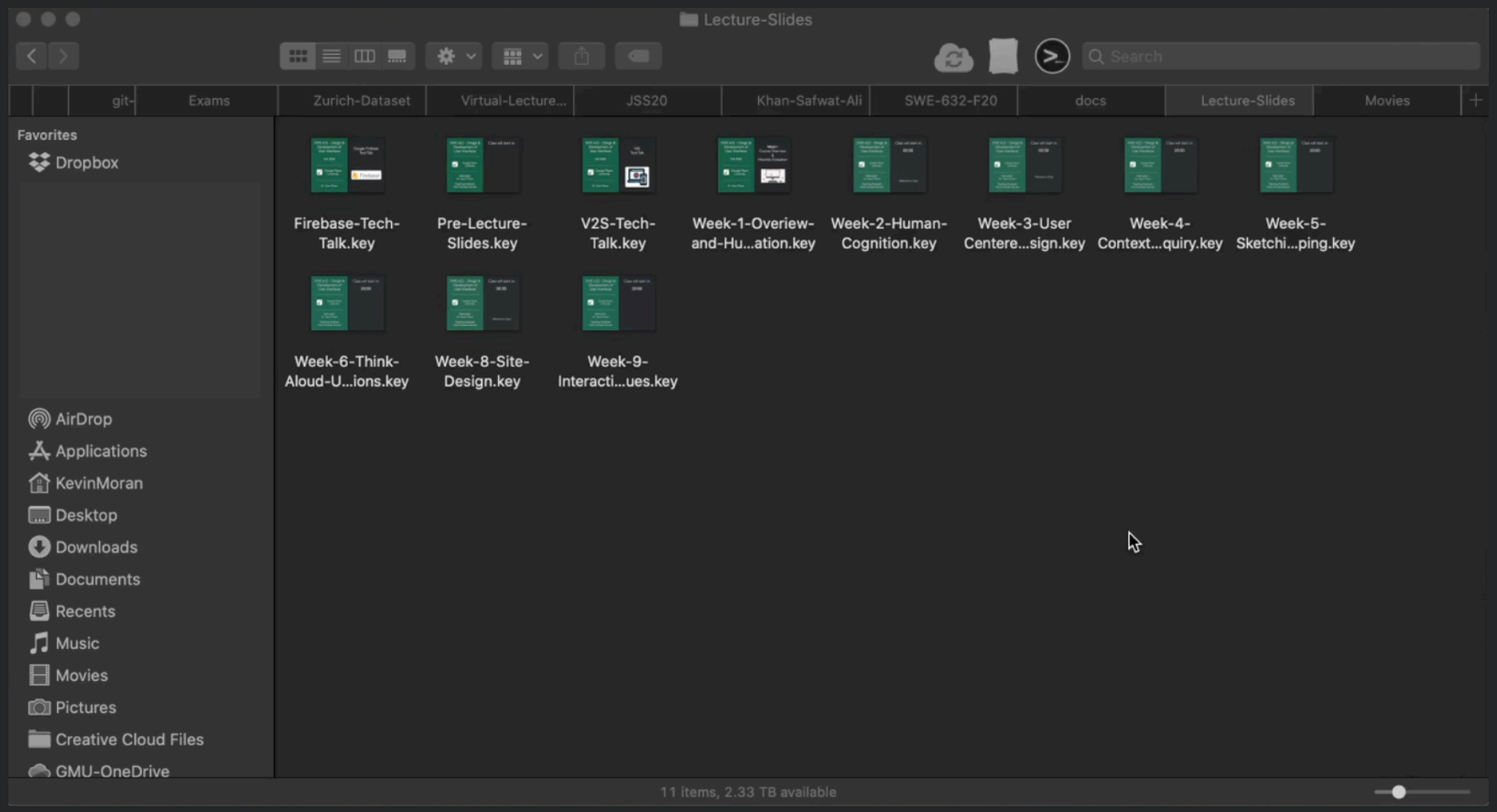
Design Implications of Fitt's Law

- ***Constraining*** movement to one dimension dramatically increases speed of actions
  - e.g., scroll bars are 1D



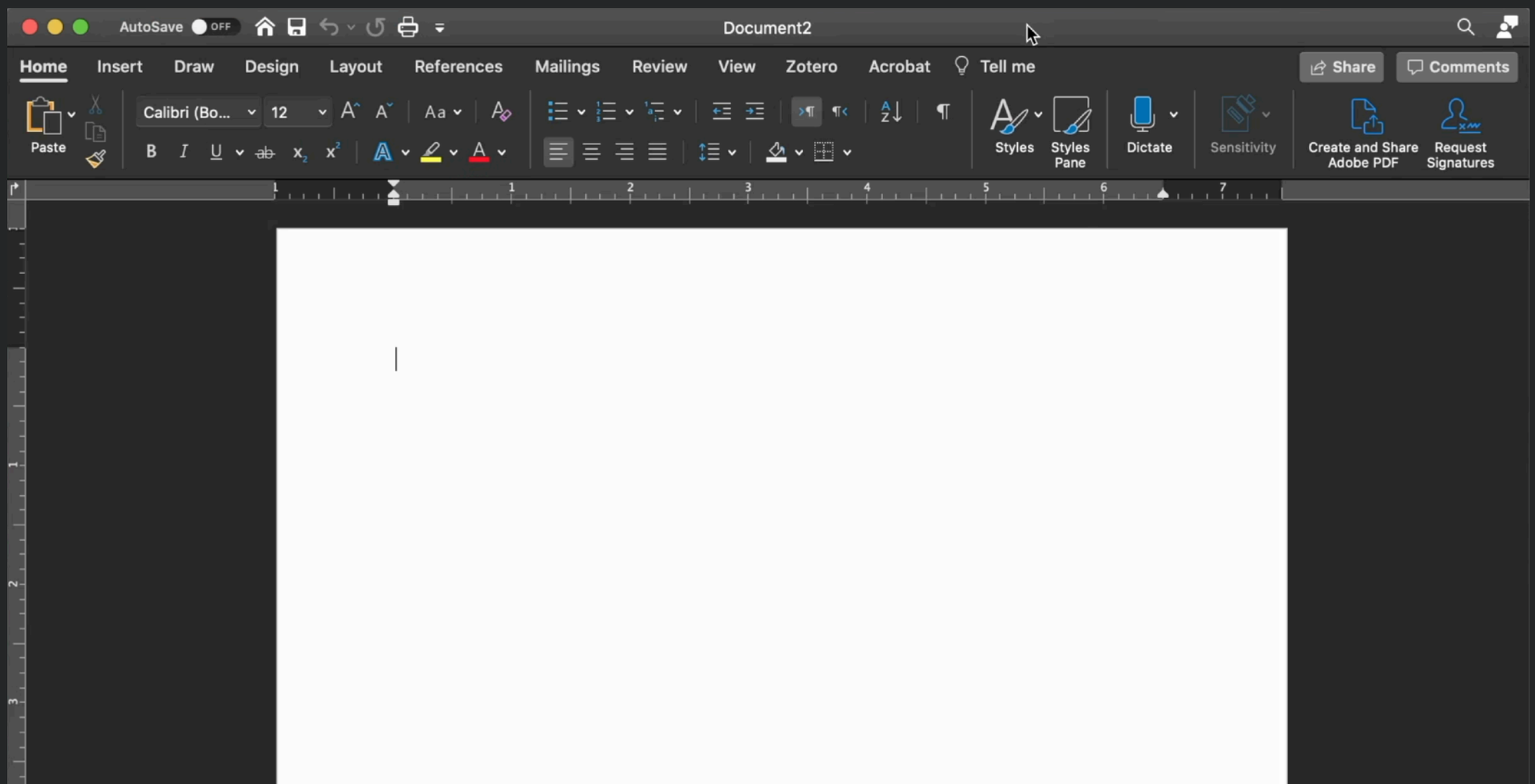
Design implications of Fitt's law

- Making controls ***larger*** reduces time to invoke actions
- Locating controls closer to user ***cursor*** reduces time
  - e.g., context menus



Design Implications of Fitt's Law

- Positioning button or control along ***edge*** of screen acts as barrier to movement, substantially reducing homing time & errors



Mobile Apps - Where's the Cursor?

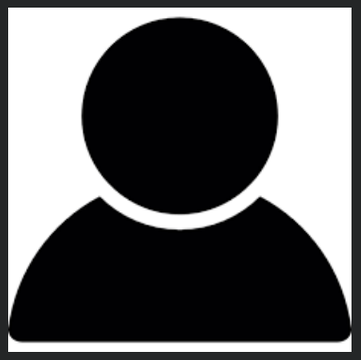
- No cursor on many mobile devices
- Cannot use dynamic hinting to determine which elements can be interacted with
  - May require more use of static hinting
- Fitt's law still applies
  - Fingers are less sensitive, hard to select small buttons, occlude elements

Supporting Users with Disabilities

- **Perception** - visual & auditory impairments
  - Blindness or visual impairments
  - Color blindness
  - Deafness & hearing limitations
- **Motion** - muscle control impairments
  - Difficulties with fine muscle control
  - Weakness & fatigue
- **Cognition** - difficulties with mental processes
  - Difficulties remembering
  - Difficulties with conceptualizing, planning, sequencing actions

Universal Design

- How can users with physical disabilities be supported in user interactions?
- Good: ***assistive design*** - offering equivalent actions for disabled users that cannot take normal actions
- Better: ***universal design*** - designing interactions so broadest set of users across age, ability, status in life can use normal actions



Example - Curb cut

- Initially designed for ***accessibility*** - support for disabled & wheel chairs
- But potentially benefits ***all users*** of public spaces - people w/ suitcases, hand carts, roller blades, bikes, …

7 Principles of Universal Design

- ***Equitable use:*** The design is useful and marketable to people with diverse abilities
- ***Flexibility in use:*** The design accommodates a wide range of individual preferences and abilities
- ***Simple and intuitive:*** Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level
- ***Perceptible information:*** The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
- ***Tolerance for error:*** The design minimizes hazards and the adverse consequences of accidental or unintended actions
- ***Low physical effort:*** The design can be used efficiently and comfortably and with a minimum of fatigue
- ***Size and space for approach and use:*** Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility

http://universaldesign.ie/What-is-Universal-Design/The-7-Principles/

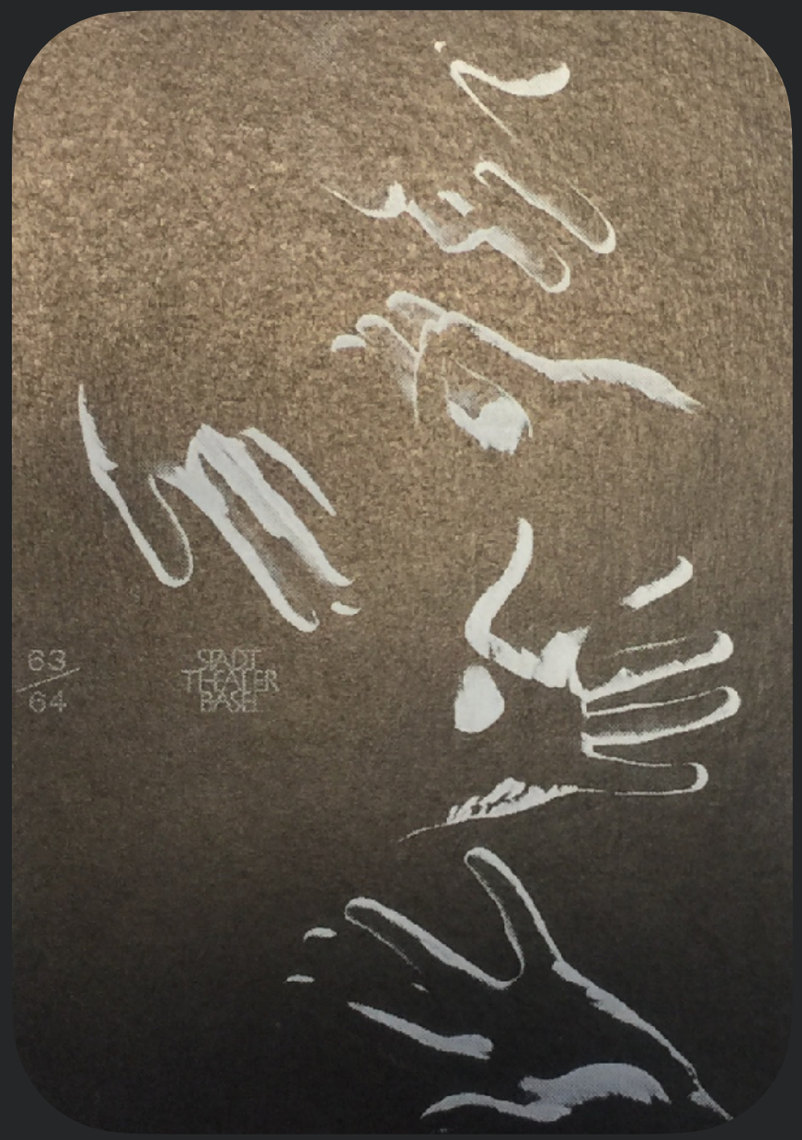
Scale, Contrast, & Proportion

Scale, Contrast, & Proportion

Information consists of differences that make a difference.
(Edward Tufte, Envisioning Information)

Individual visual variables of design that encode information

Terminology



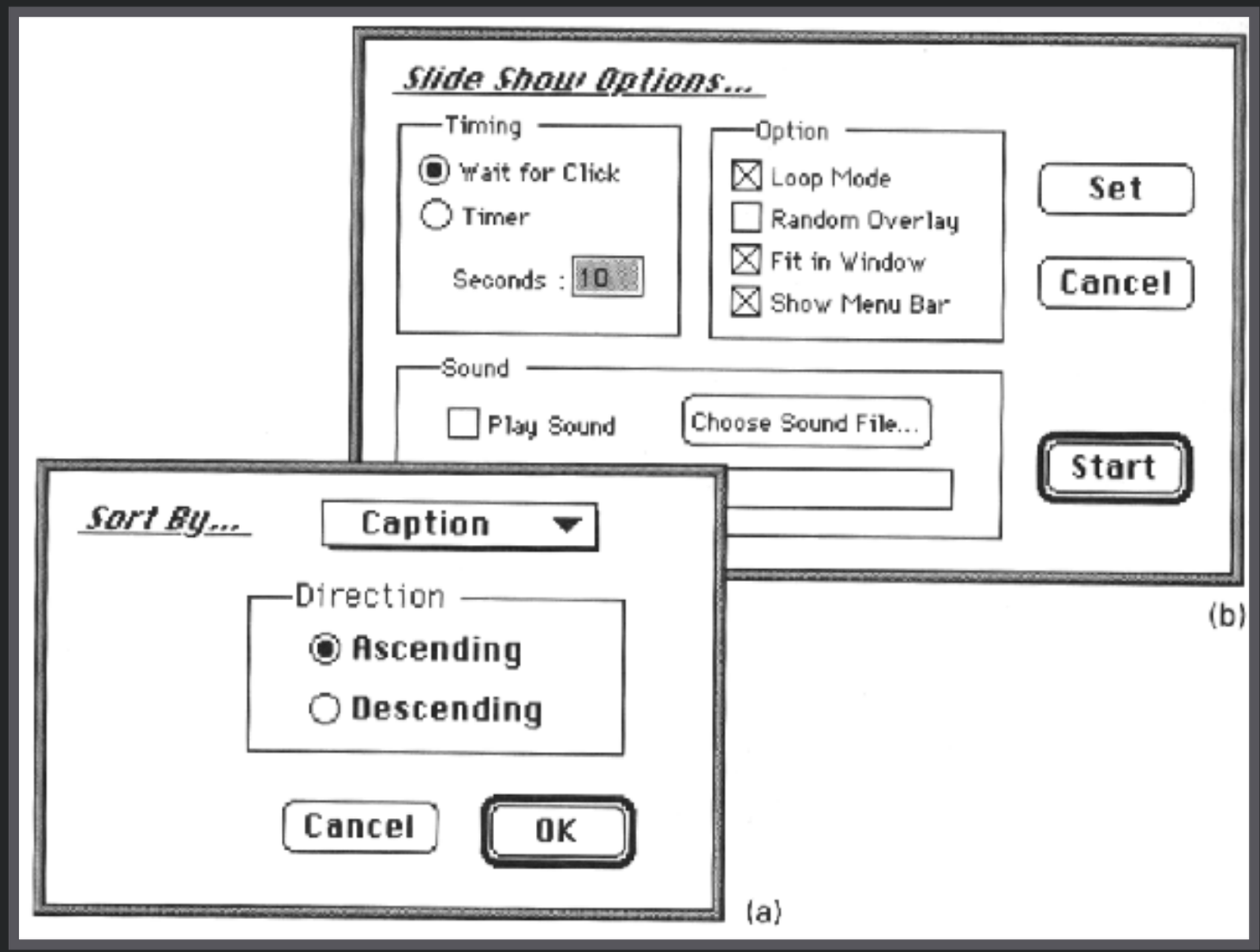
- Scale - ***relative*** size or magnitude of element in comparison to related elements
- Contrast - visually noticeable ***distinctions*** along a common visual dimension
- Proportion - ratio and ***balance*** between elements
- Emphasis - contrasts can emphasize important elements or areas & add visual ***interest*** by creating tension & drama

Principles

- ***Clarity*** - contrasts should be clear and easily differentiated, not slight and subtle
- ***Harmony*** - proportions and ratios should be harmonious
- ***Activity*** - use contrasts to maintain orientation & context within design
- ***Restraint*** - contrasts should be conscious, strong, few in number, and never overwhelming

Error - Excessive Typographic Contrasts

5 different types sizes in 3 different fonts (!!)



Layers

- Contrasting color, value, texture can segregate information into separate layers

- Supports ***overlapping*** information in displays, allowing selective processing of specific sets of elements

- Allows different layers to be read and interpreted ***separately***

Creating Layers

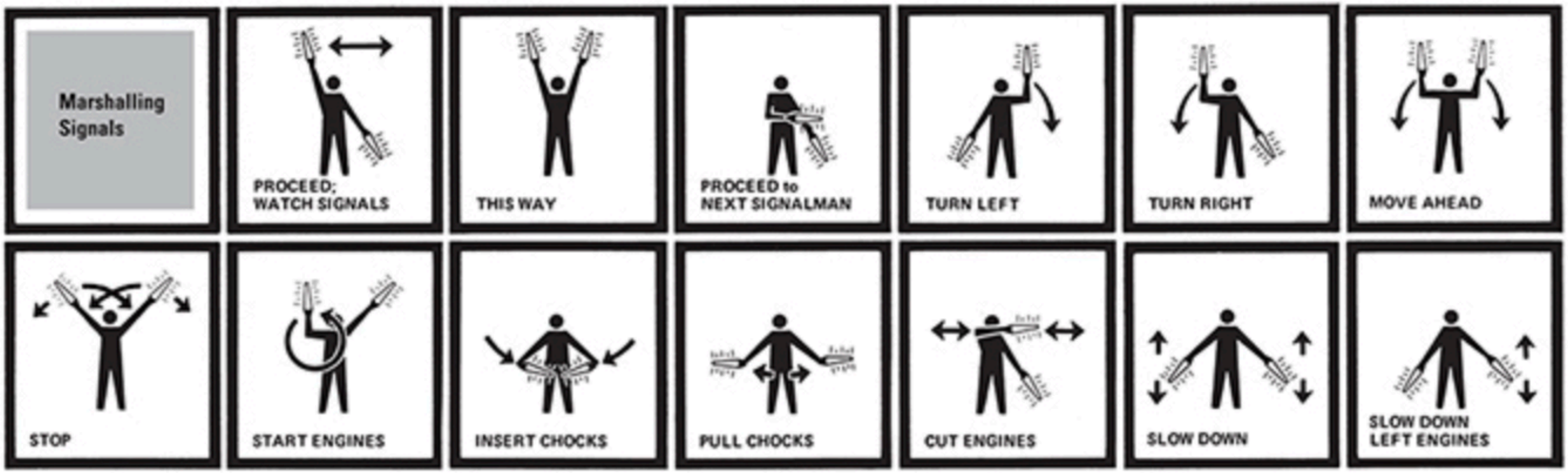
1. Group items into categories based on intended use

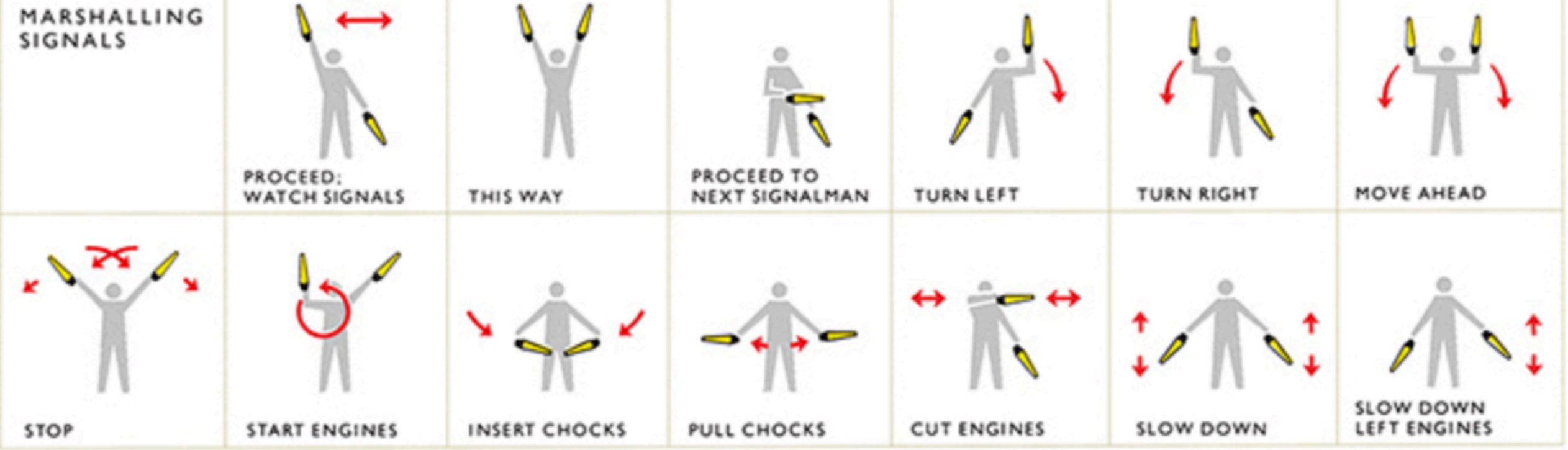
2. Determine rank & importance of groups

3. Use perceptual variables (size, value, hue, etc.) to establish layering effect

4. Maximize differences between groups while minimizing differences within groups

5. Use squint test to ensure elements in group retain together but visually separated


Marshalling Signals
PROCEED; WATCH SIGNALS
THIS WAY
PROCEED to NEXT SIGNALMAN
TURN LEFT
TURN RIGHT
MOVE AHEAD
STOP
START ENGINES
INSERT CHOCKS
PULL CHOCKS
CUT ENGINES
SLOW DOWN
SLOW DOWN LEFT ENGINES


MARSHALLING SIGNALS
PROCEED; WATCH SIGNALS
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PROCEED TO NEXT SIGNALMAN
TURN LEFT
TURN RIGHT
MOVE AHEAD
STOP
START ENGINES
INSERT CHOCKS
PULL CHOCKS
CUT ENGINES
SLOW DOWN
SLOW DOWN LEFT ENGINES

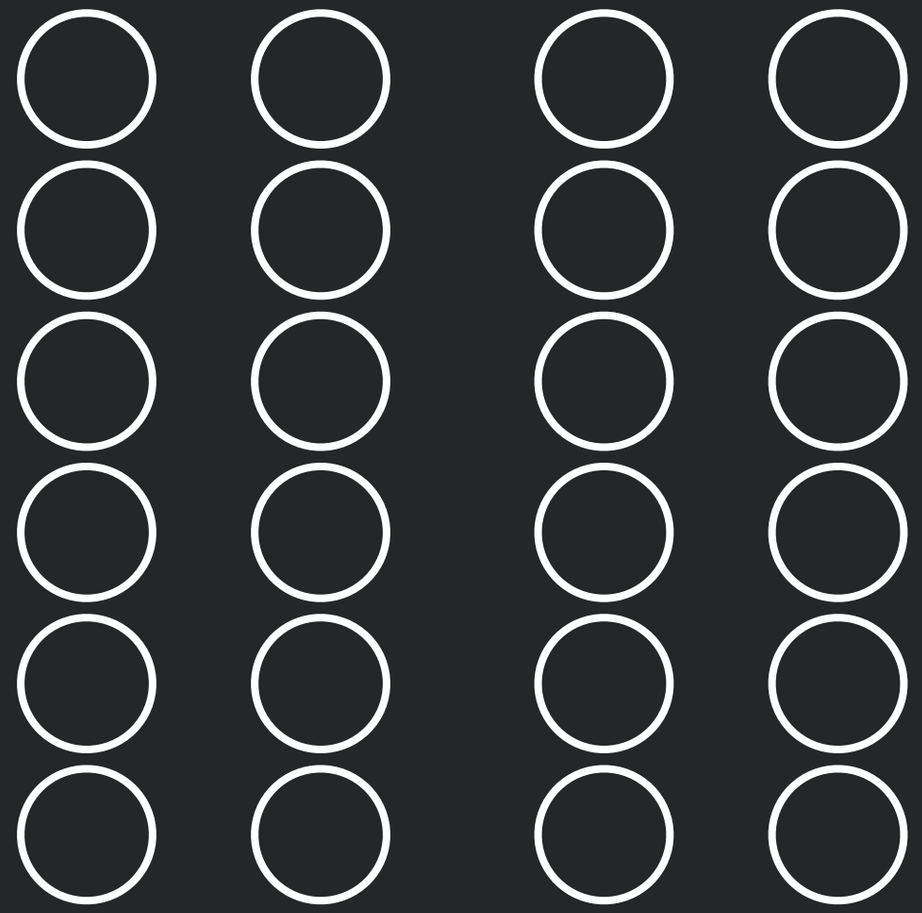
Organization & Structure

Organization & Structure

- Organization needs to be ***designed***
- Benefits
  - Unity - ties together related elements so that they work **together**
  - Integrity & readability - offers structure that helps user to easily scan & make comparisons
  - Control - determines where user will focus **attention** in the design
- Gestalt -> psychology of perception

Gestalt Principle - Proximity

- Elements associated ***most*** strongly w/ nearby elements

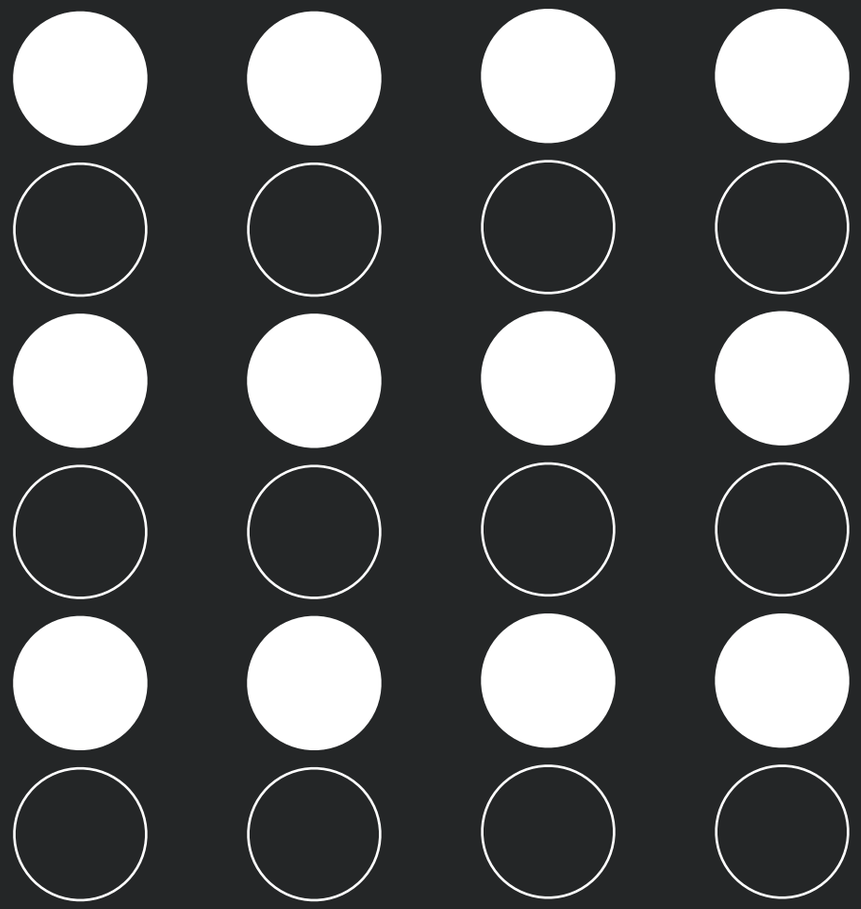


parsed as 4 columns based on close vertical spacing
then parsed as two sets of two columns based on spacing

Gestalt Principle - Similarity

- Elements associated more strongly when share common visual attributes than when they differ

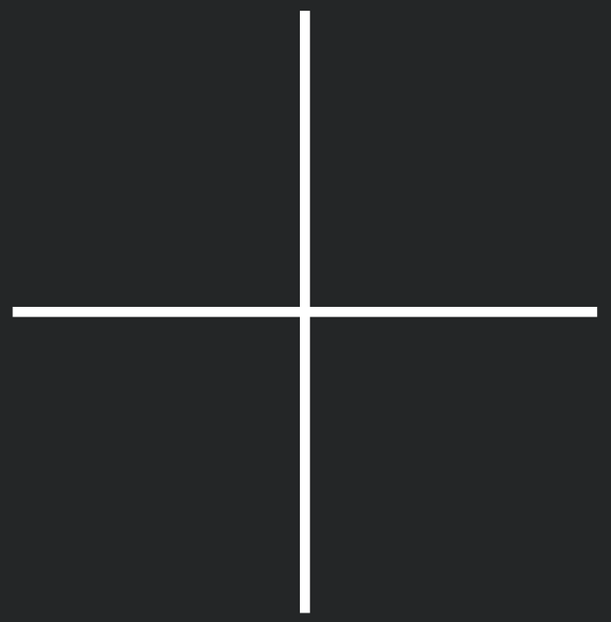
parsed as rows based on fill similarity,
despite closer column spacing



Gestalt Principle - Continuity

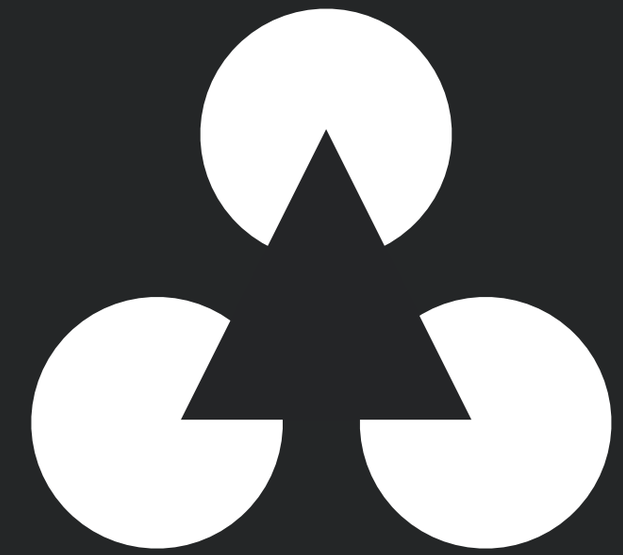
- Preference for ***simplest*** physical explanation of complex figure

parsed as two lines, rather than 4 separate lines or 4 opposing angles



Gestalt Principle - Closure

- Preference to interpret figures as complete, even when missing information

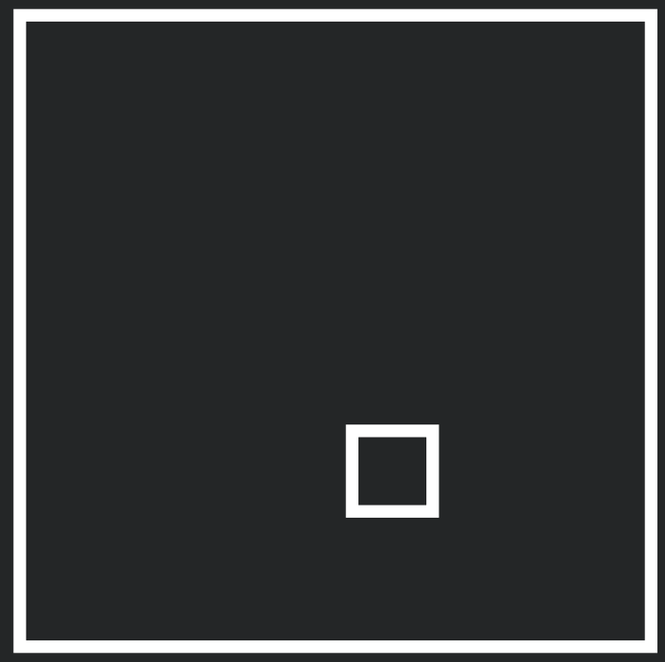


Parsed as triangle superimposed on 3 complete circles, even though none of these is actually present

Gestalt Principle - Area

- Preference to interpret smaller overlapping elements as figure, larger as ground

Small rectangle parsed as small rectangle on top of larger, rather than hole



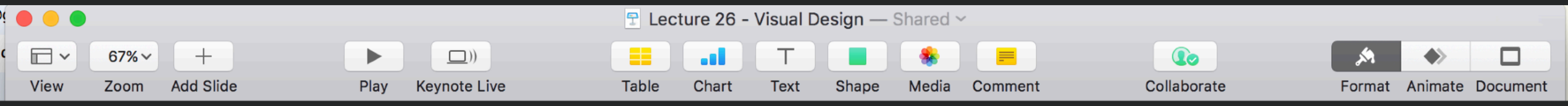
Gestalt Principle - Symmetry

- Preference to interpret ambiguous form as multiple symmetric elements

Parsed as two overlapping objects rather than 3 separate shapes

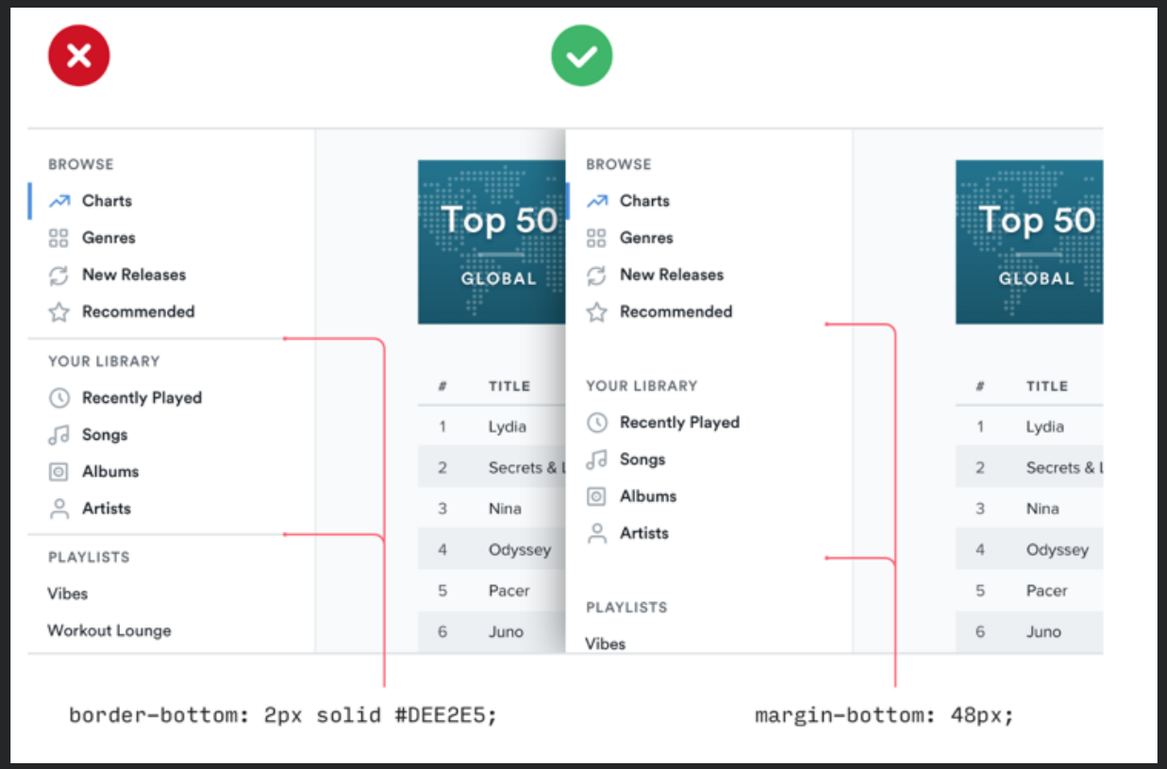
Grouping

- Binding UI elements tightly together while distinguishing them from surrounding controls
- “Showing” not “telling”
- Can be achieved through
  - Bounding boxes (not recommended)
  - Negative space & contrasts
  - Arrangement & alignment

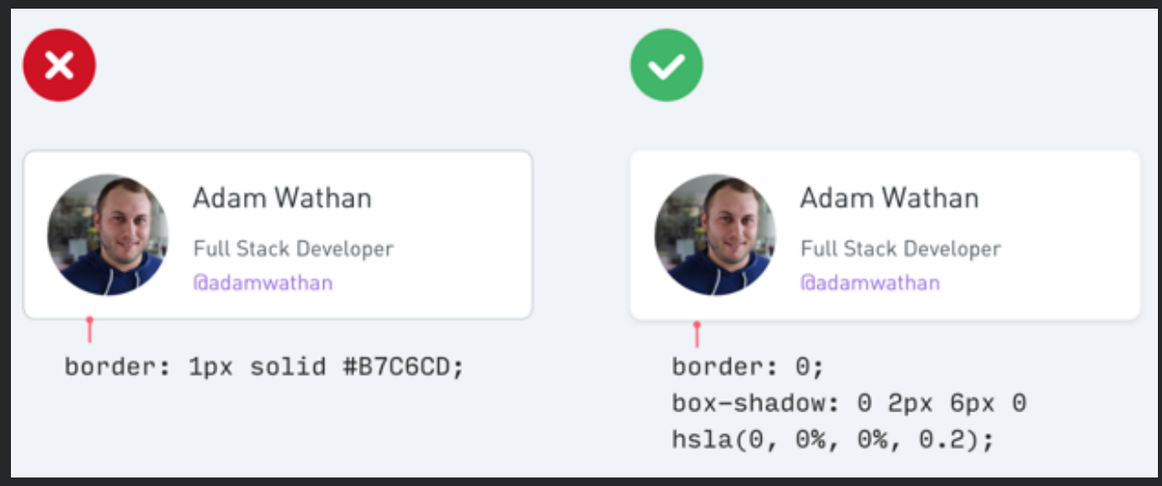


Use Fewer Borders

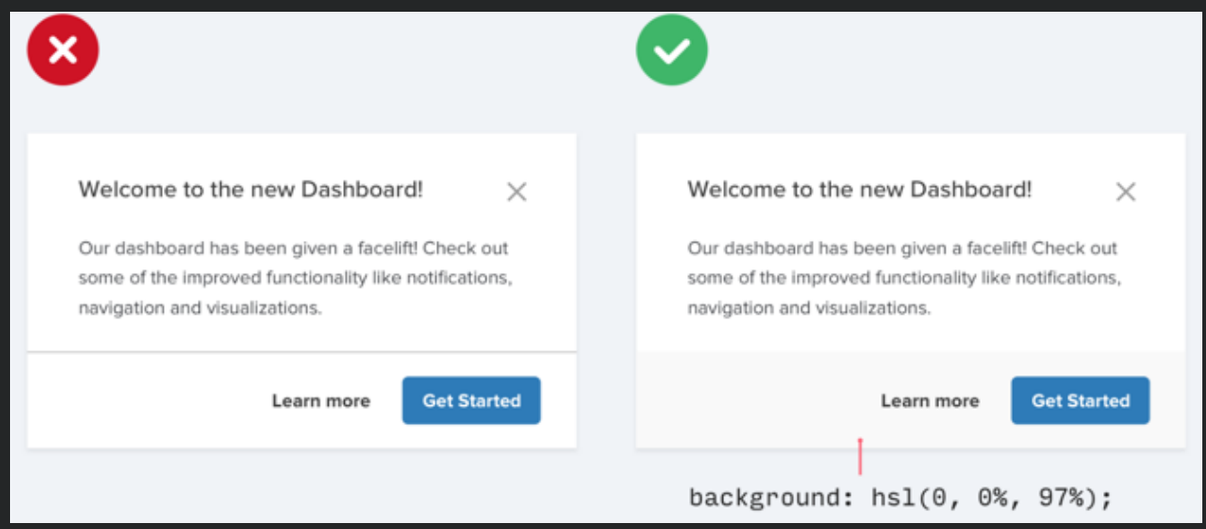
https://medium.com/refactoring-ui/7-practical-tips-for-cheating-at-design-40c736799886



negative space



box shadows



different backgrounds

Hierarchy

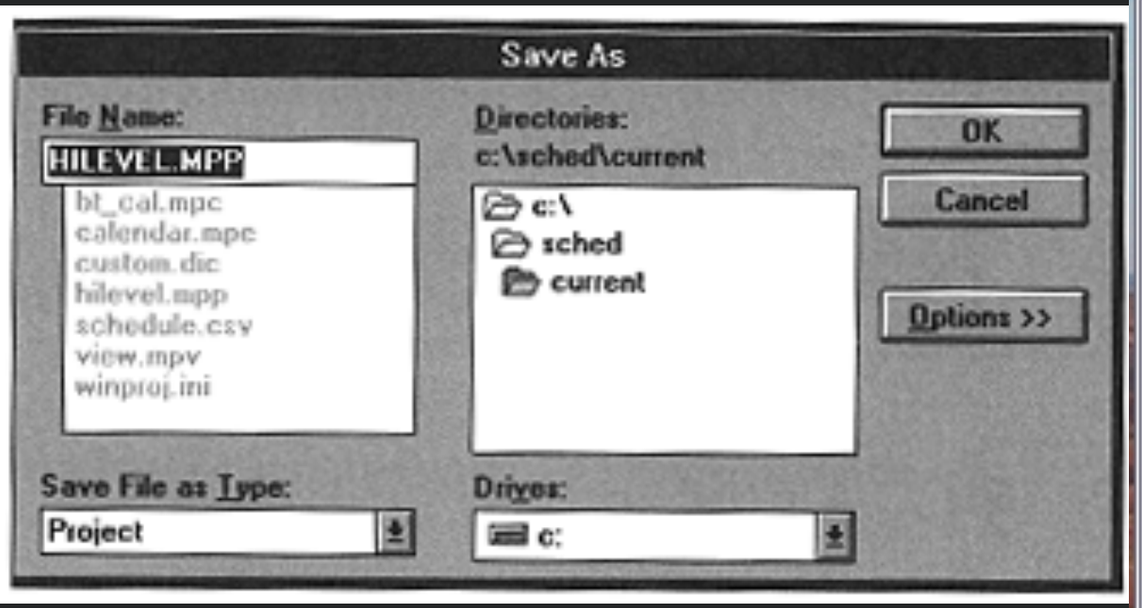
Order groups based on perceptual prominence corresponding to intended reading sequence

Can help solve “skimming” problems

Structure can help people focus attention on key parts

Key points might **get lost though.**

But bolding helps! Plus this obnoxious red arrow and text in a totally different font!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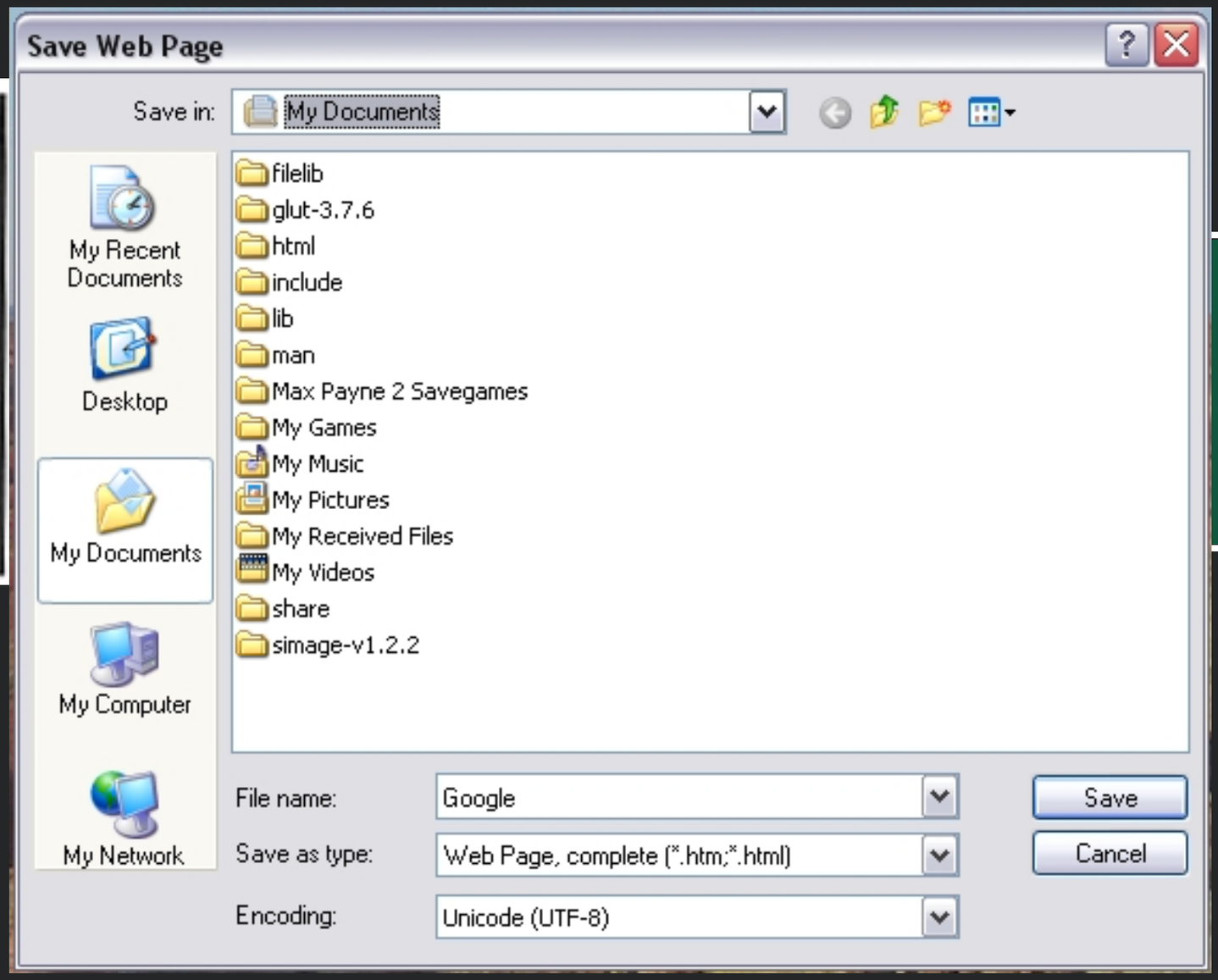
File Name:
HILEVEL.MPP
bt_cal.mpc
calendar.mpc
custom.dic
hilevel.mpp
schedule.csv
view.mpv
winproj.ini
Directories:
c:\sched\current
c:\
sched
current
OK
Cancel
Options >>
Save File as Type:
Project
Drives:
c:


Save Web Page
Save in:
My Documents
My Recent Documents
Desktop
My Documents
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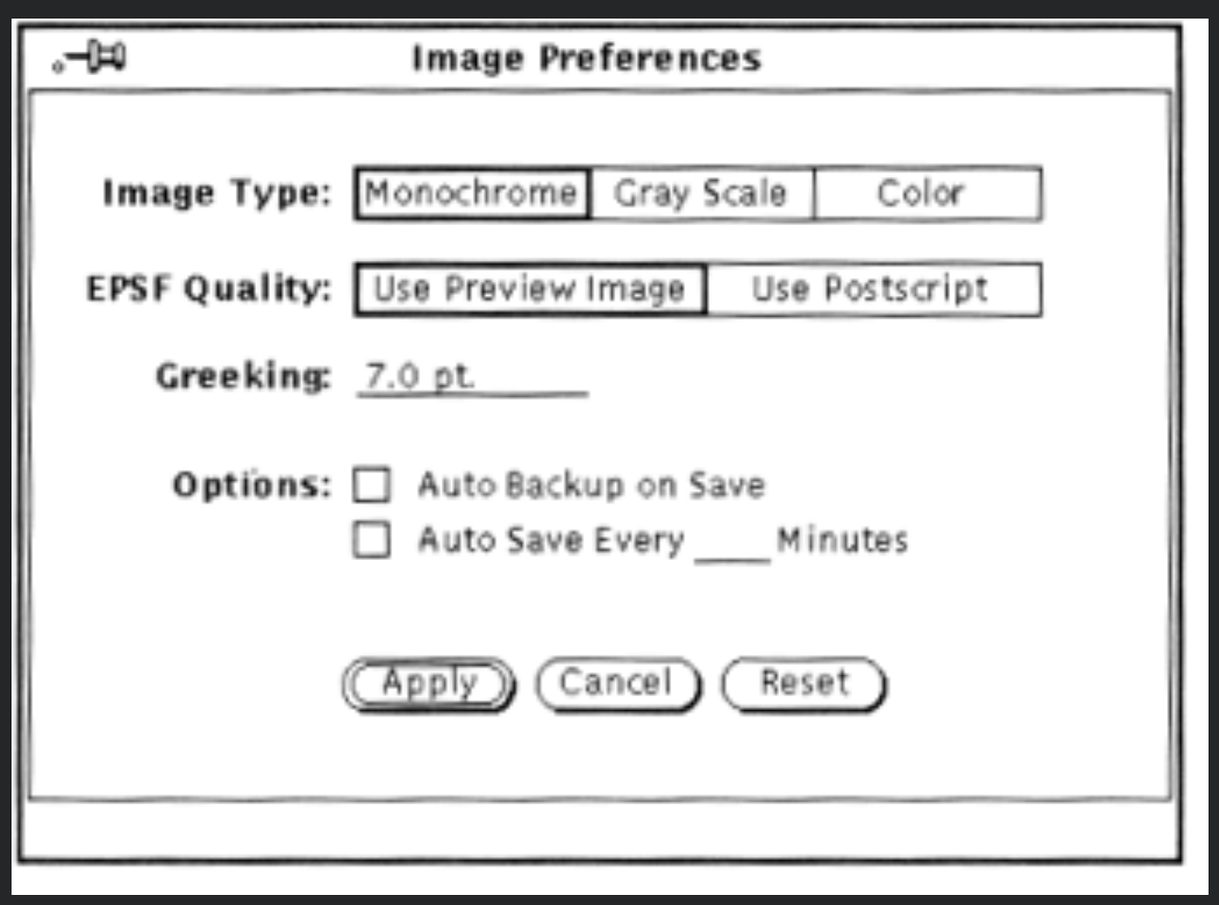
Max Payne 2 Savegames
My Games
My Music
My Pictures
My Received Files
My Videos
share
simage-v1.2.2
File name:
Google
Save as type:
Web Page, complete (*.htm;*.html)
Encoding:
Unicode (UTF-8)
Save
Cancel

Use Negative Space

- Directs ***attention*** to critical regions of display

1. Review design, prioritizing groups

2. Add extra ***space*** to ensure spatial separation & emphasis, particularly for important elements



Week 14: Information Visualization

Amplifying Cognition

- Information Visualization can amplify cognition by:

  1. Increasing the memory and processing resources available to users

  2. Reducing the search for information

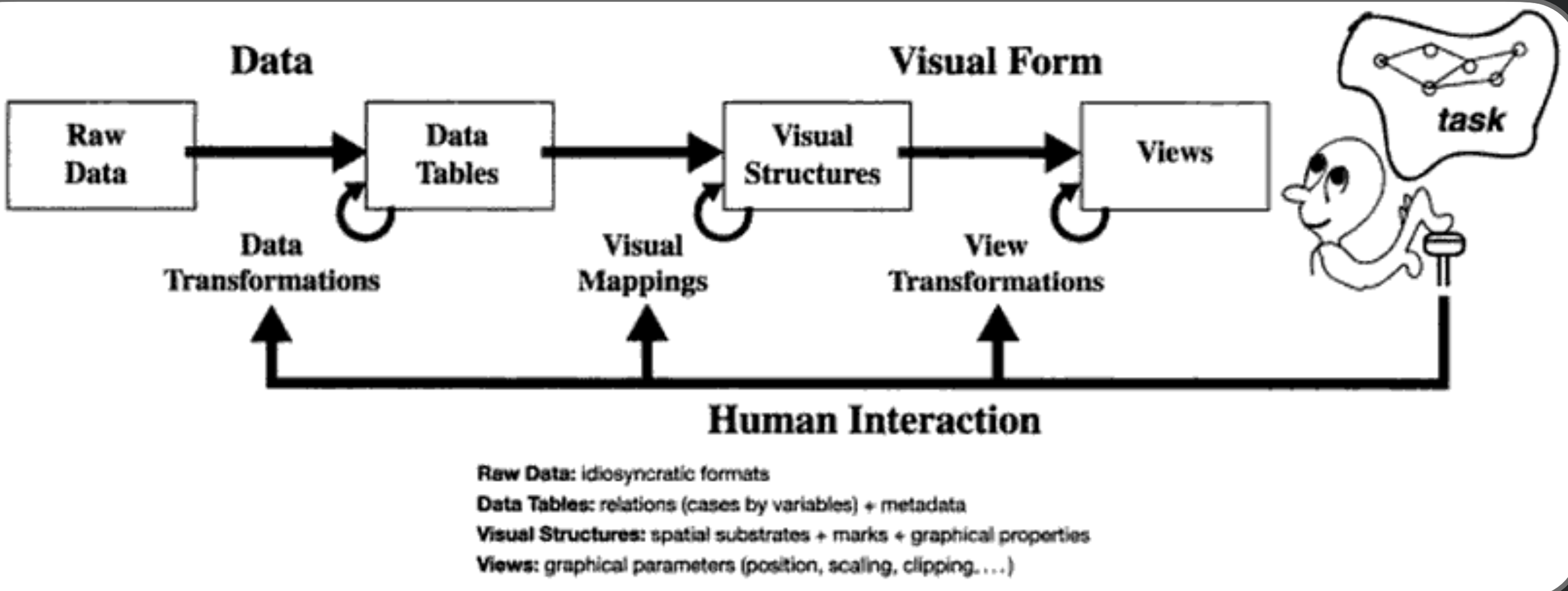
  3. Using visual representations to enhance the detection of patterns

  4. Enabling perceptual inference

  5. Using perceptual attention mechanisms for monitoring

  6. Encoding Information in a manipulable medium

Designing an Information Visualization



Types of Raw Data

- Nominal - unordered set ***without*** a quantitative value
  - Gender: male, female
  - Hair color: brown, black, blonde, gray, orange, ...
- Ordinal - ***ordered*** set, with no meaning assigned to differences
  - How do you feel today: very unhappy, unhappy, ok, happy, very happy
  - Undefined how much better happy is than ok
- Quantitative - ***numeric*** value
  - Height, weight, distance, ...

Data Transformations

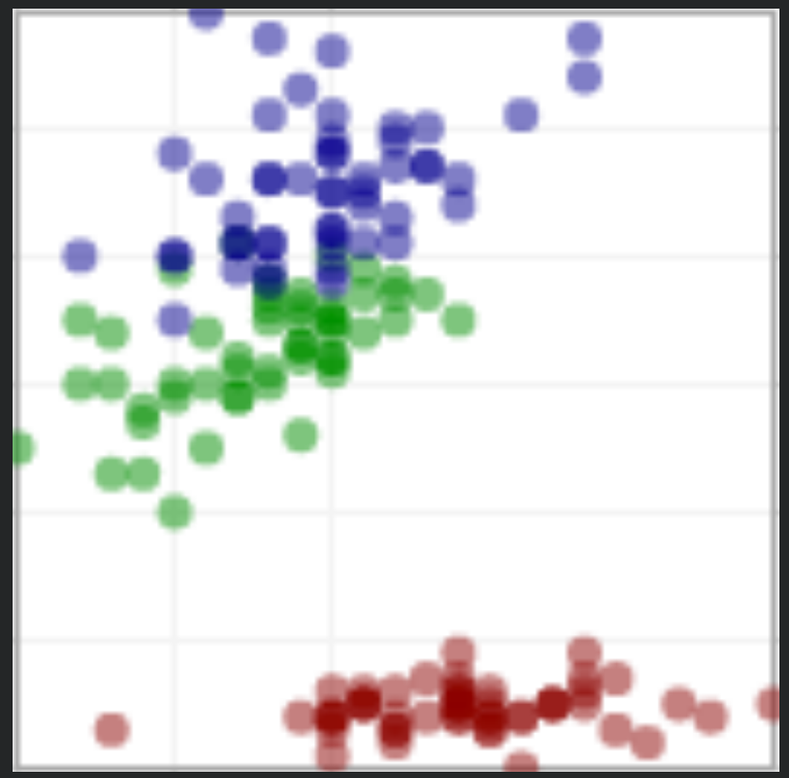
- Classing / binning: Quantitative —> ordinal
  - Maps ranges onto ***classes*** of variables
    - Can also count # of items in each class w/ histogram
- Sorting: Nominal —> ordinal
  - Add order between items in sets
- Descriptive statistics: mean, average, median, max, min, …

Visual Structures

- 3 components
  - spatial substrate
  - marks
  - marks' graphical properties

Spatial Substrate

- Axes that divide space
- Types of axes - unstructured, nominal, ordinal, quantitative
- Composition - use of multiple orthogonal axes (e.g., 2D scatterplot, 3D)



Marks

- Points (0D)
- Lines (1D)
- Areas (2D)
- Volumes (3D)

Marks' Graphical Properties

- Quantitative (Q), Ordinal (O), Nominal (N)
- Filled circle - good; open circle - bad

	Spatial	Object
Extent	(Position) —|—|—|—| Size ● ● • ·	Gray Scale ■ ■ ■ □
Dif-ferential	Orientation — / | \	Color ■ ■ ■ ■ Texture ■ ■ ■ ■ Shape ■ ★ ● ◆

Effectiveness of Graphical Properties

- Quantitative (Q), Ordinal (O), Nominal (N)
- Filled circle - good; open circle - bad

	Spatial	Q	O	N	Object	Q	O	N
Extent	(Position)	●	●	●	Grayscale	◑	●	○
	Size	●	●	●				
Differential	Orientation	◑	◑	●	Color	◑	◑	●
					Texture	◑	◑	●
					Shape	○	○	●

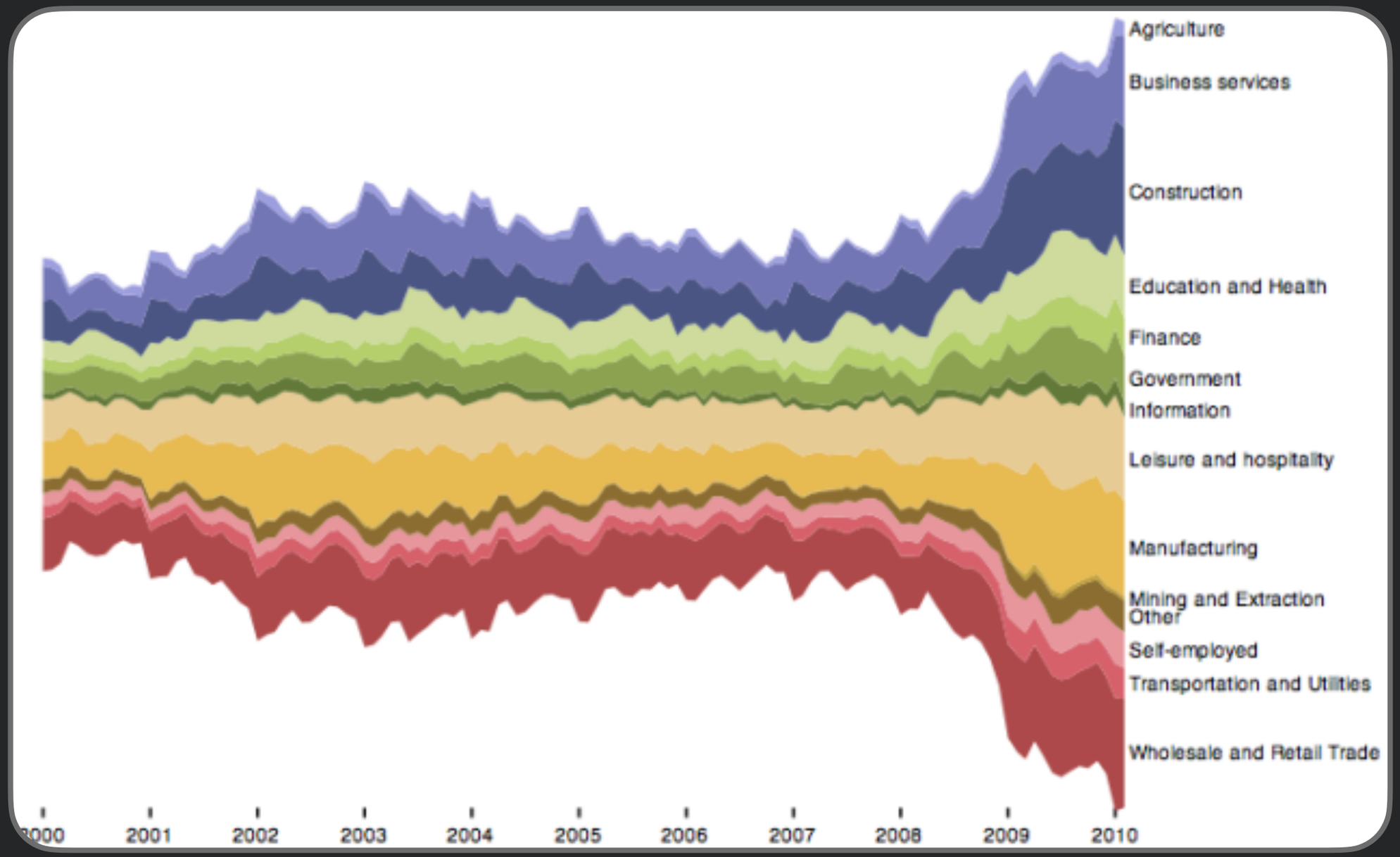
Animation

- Visualization can change over time
- Could be used to encode data as a function of time
  - But often not effective as makes direct comparisons hard
- Can be more effective to animate transition from before to after as user configures visualization

Time-series Data

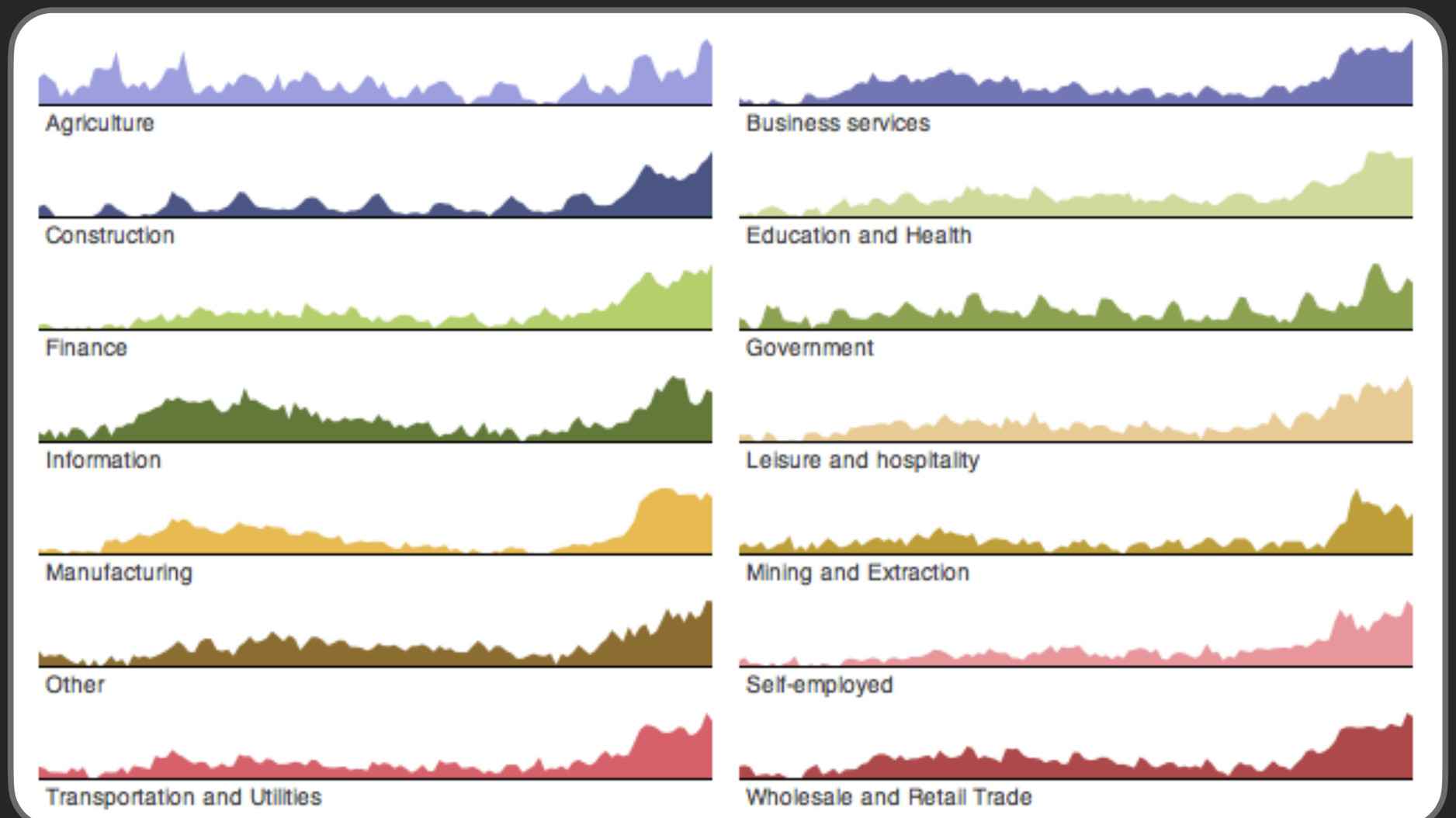
Stacked Graph

- Supports visual summation of multiple components



Small Multiples

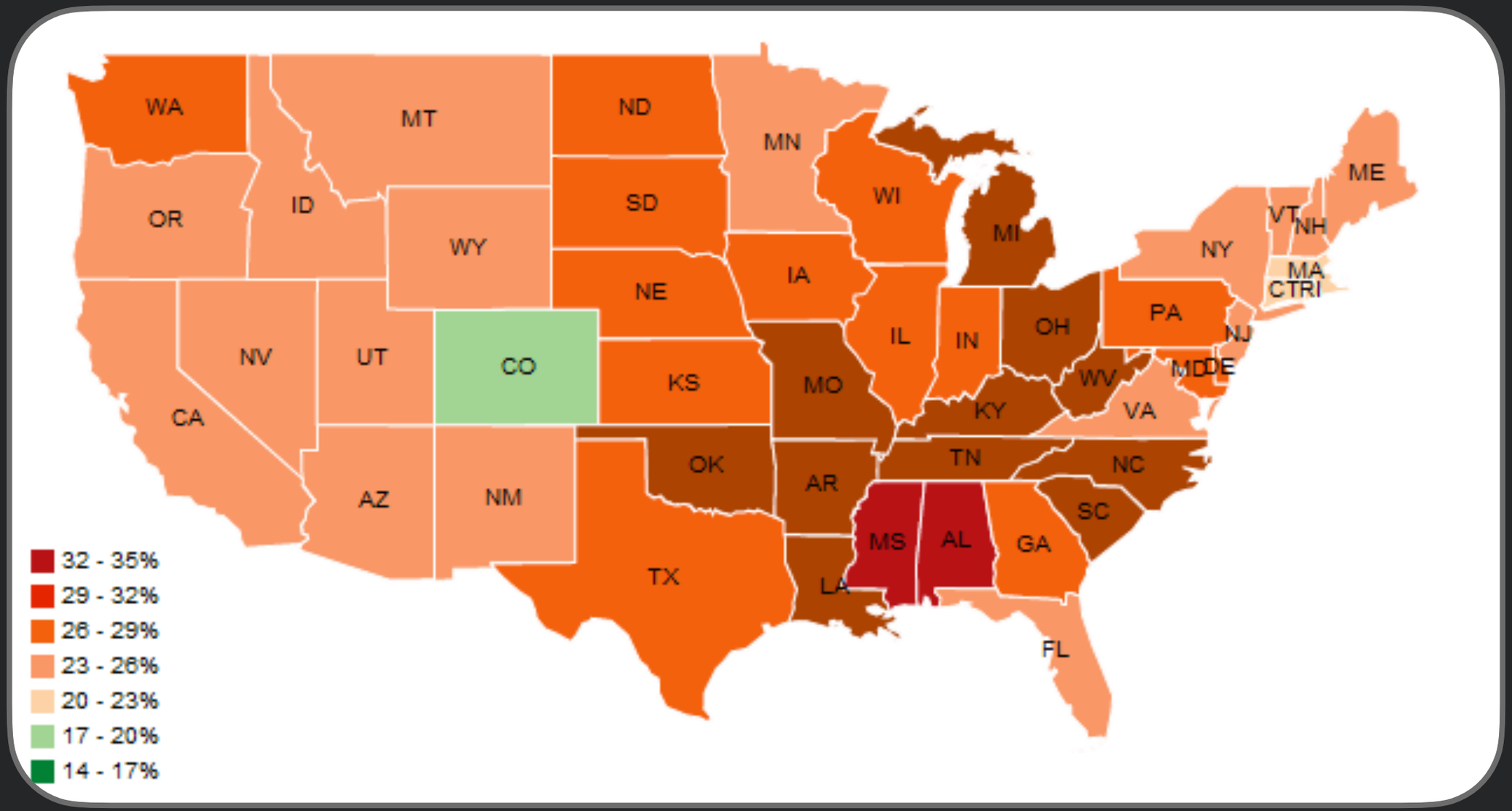
- Supports separate comparison of data series
- May have better legibility than placing all in single plot



Maps

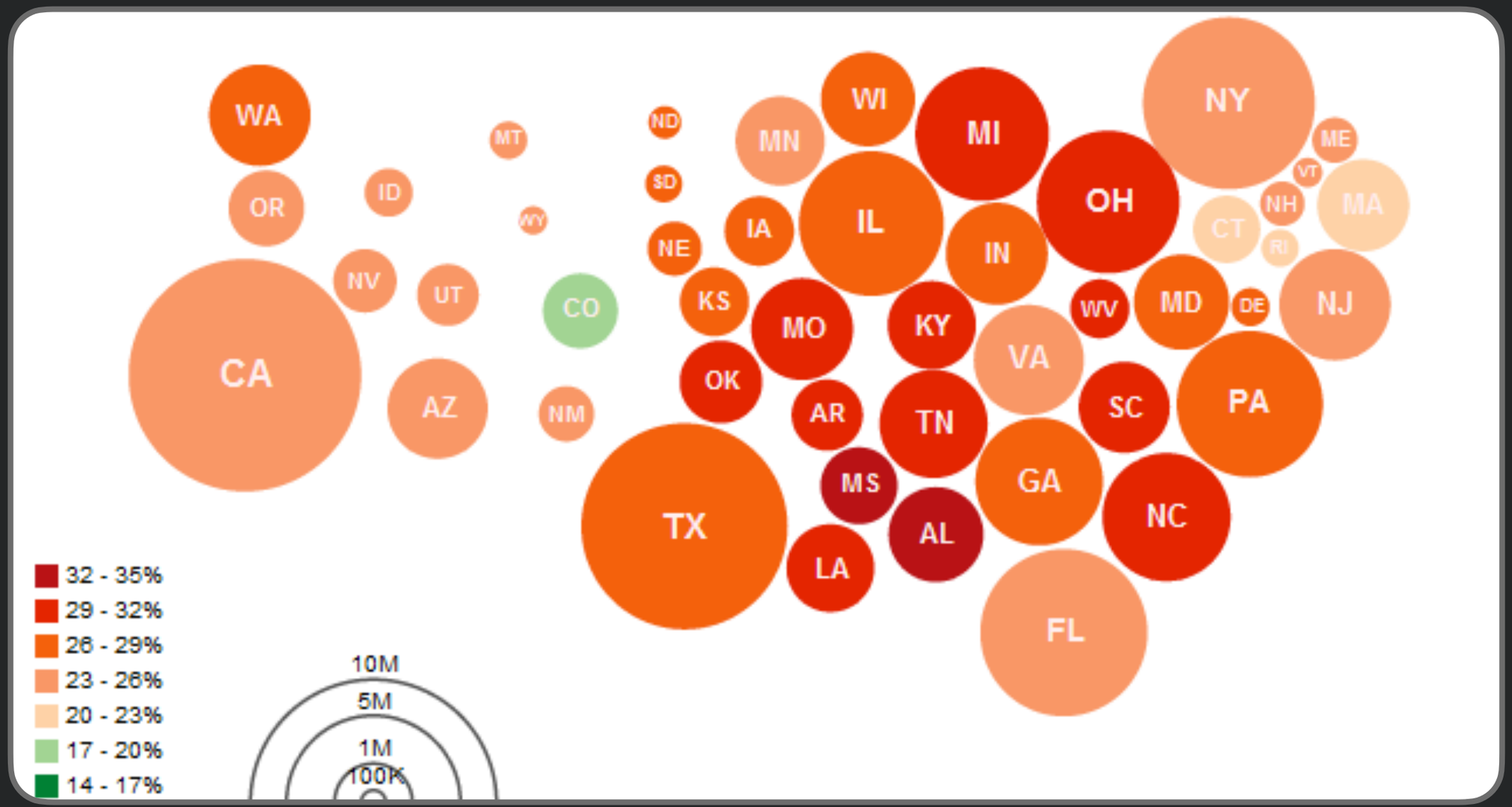
Choropleth Map

- Groups data by area, maps to color



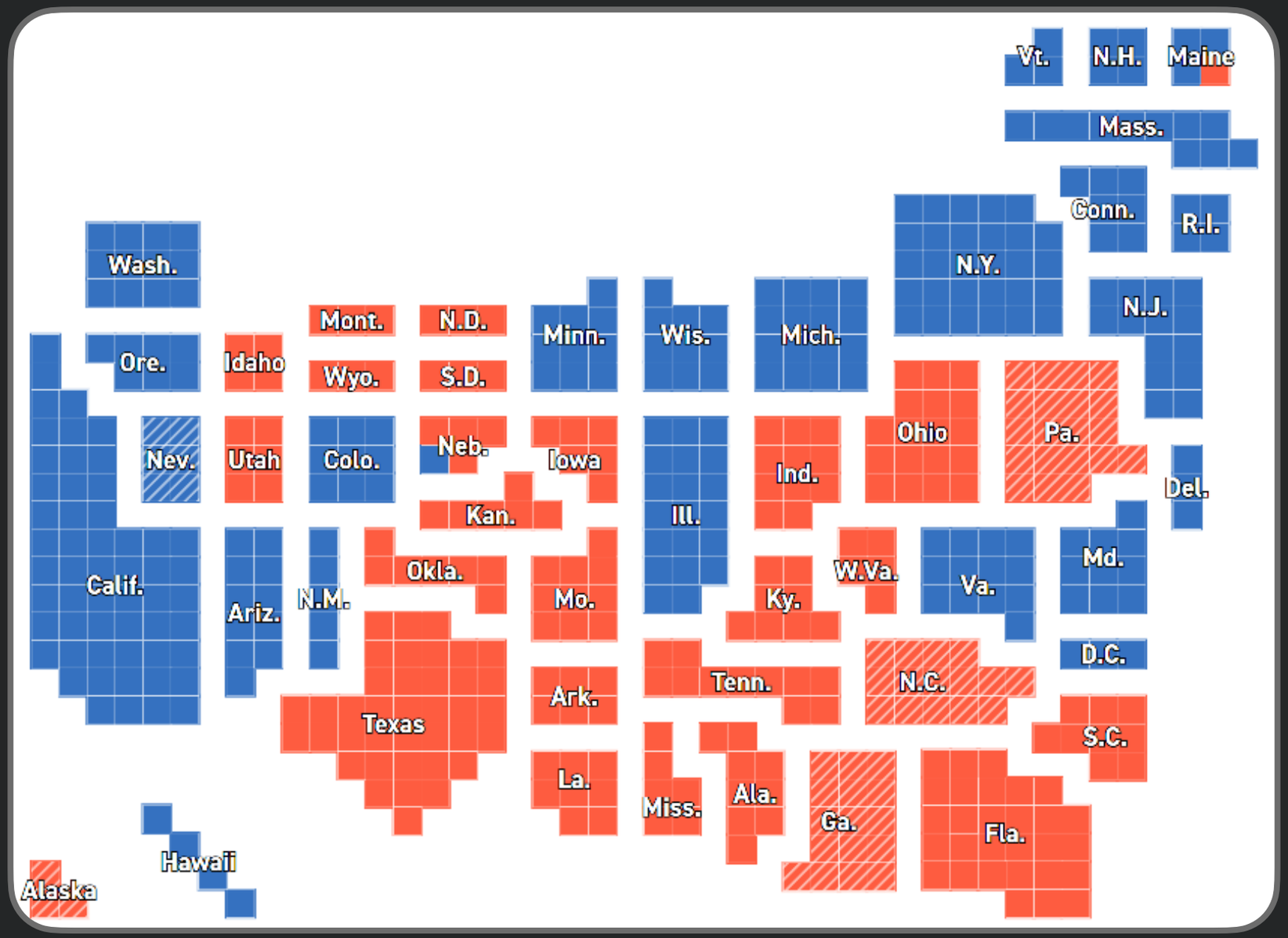
Cartograms

- Encodes two variables w/ size & color



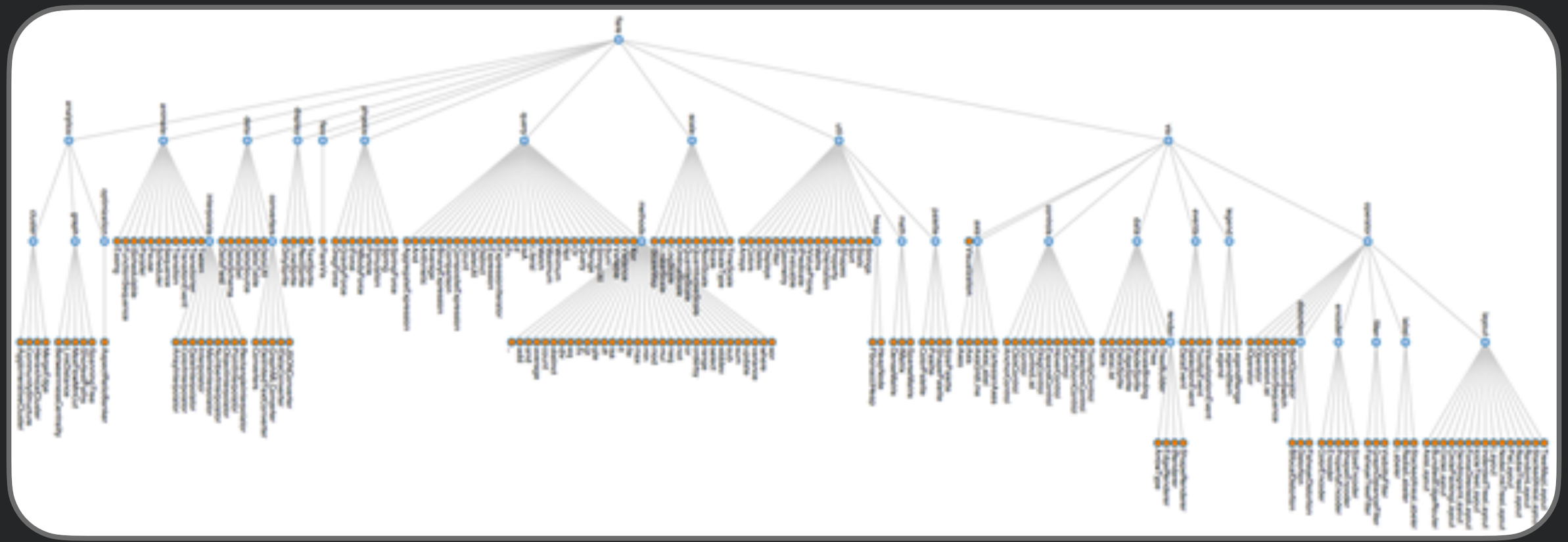
Cartograms

- Encodes two variables w/ size & color



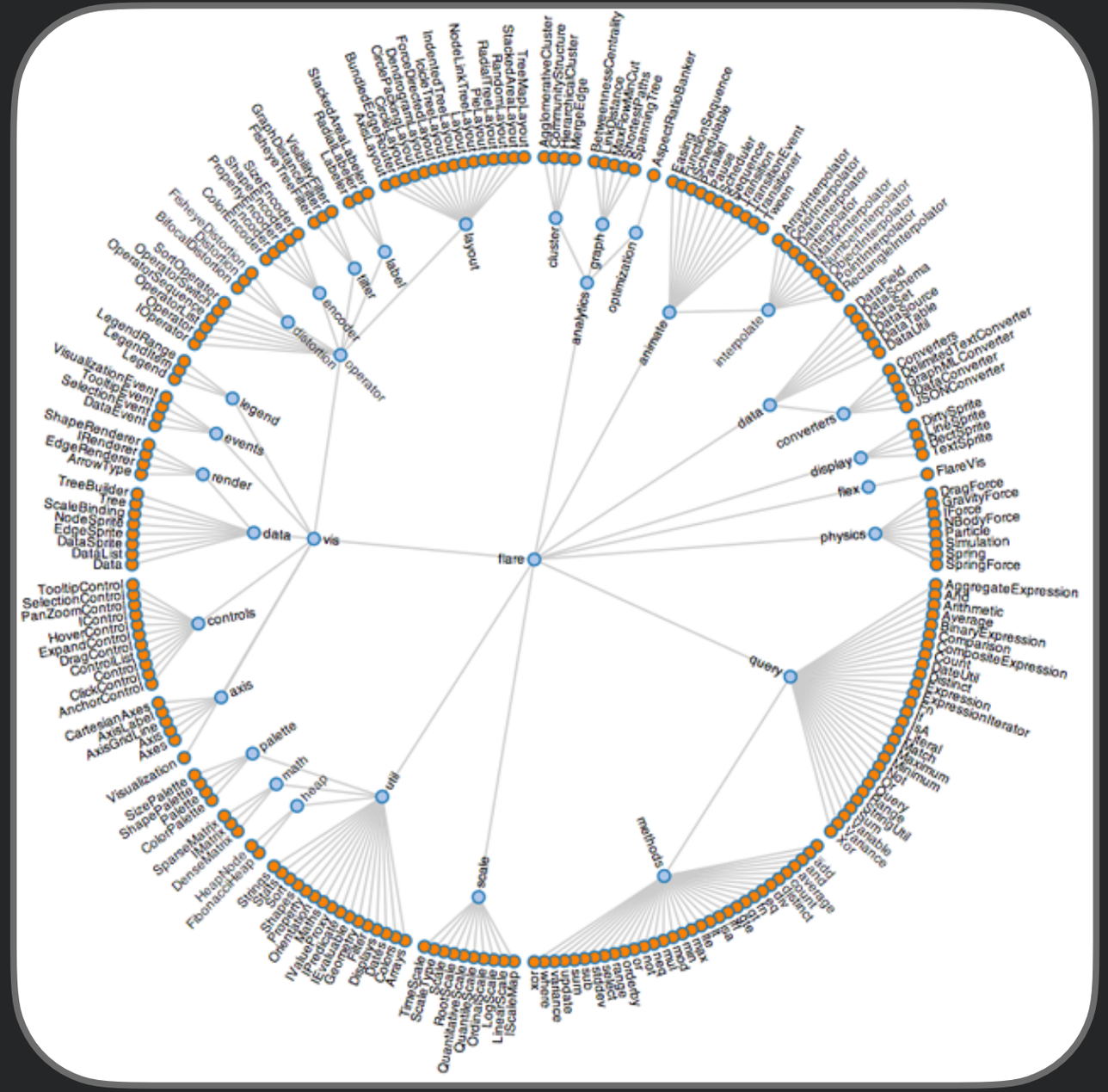
Hierarchies

Node Link Diagram

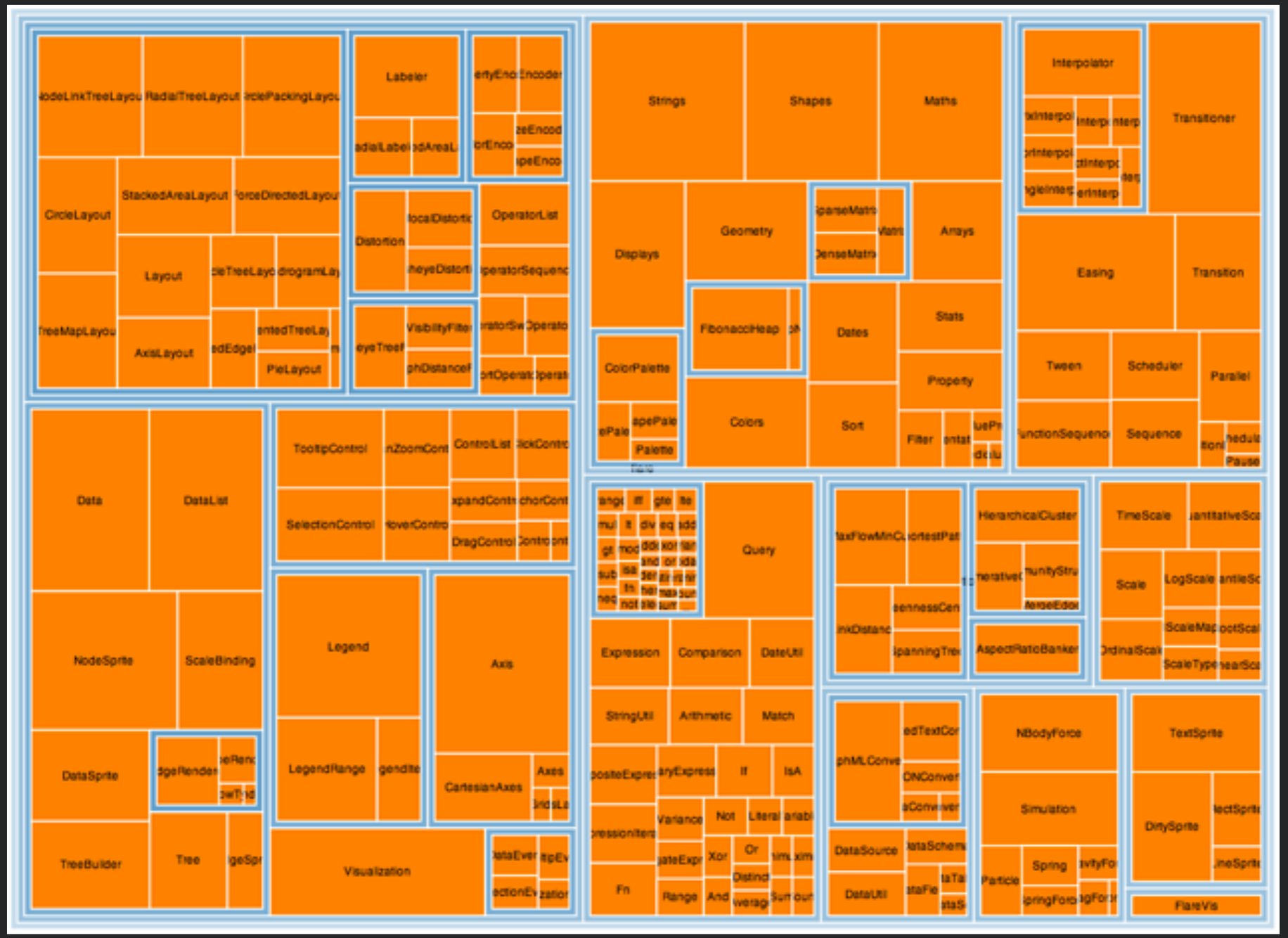


Dendrogram

- Leaf nodes of hierarchy on edges of circle



Treemaps


Labeler
Strings
Shapes
Maths
Interpolator
Transitioner
CircleLayout
StackedAreaLayout
Layout
AxisLayout
PieLayout
Distortion
OperatorList
Displays
Geometry
Arrays
Easing
Transition
FibonacciHeap
Dates
Stats
Tween
Scheduler
Parallel
ColorPalette
Palette
Colors
Sort
Property
Filter
Sequence
Data
DataList
NodeSprite
ScaleBinding
DataSprite
TreeBuilder
Tree
Visualization
TooltipControl
ControlList
SelectionControl
DragControl
Legend
LegendRange
Axis
CartesianAxes
Axes
Query
Expression
Comparison
DateUtil
StringUtil
Arithmetic
Match
Variance
Not
Or
Xor
Distinct
Range
And
IsA
Fn
HierarchicalCluster
AspectRatioBanker
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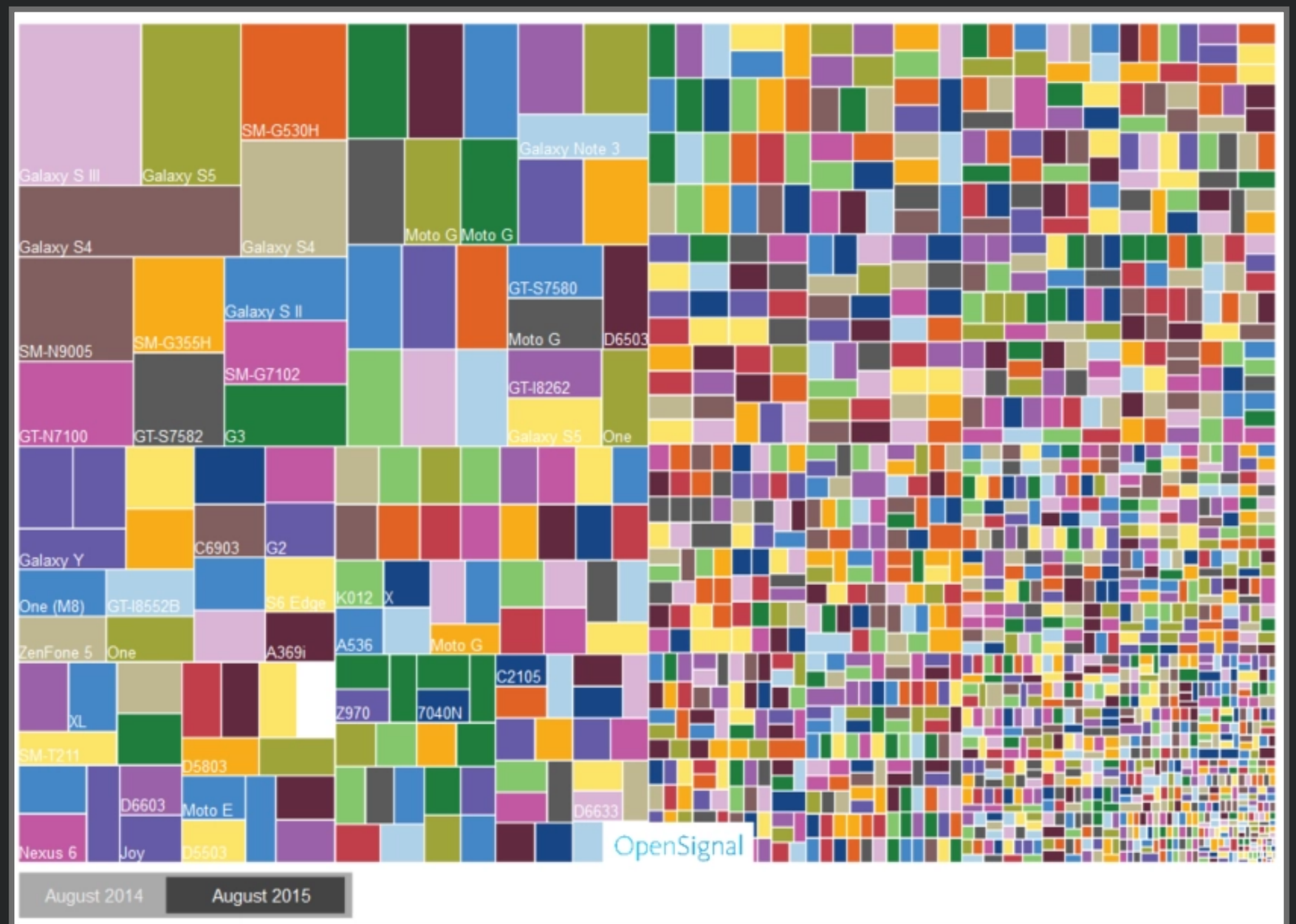
Spring
Particle
TextSprite
DirtySprite
FlareVis
DataSource
DataUtil

Treemaps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Galaxy S4
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GT-S7580
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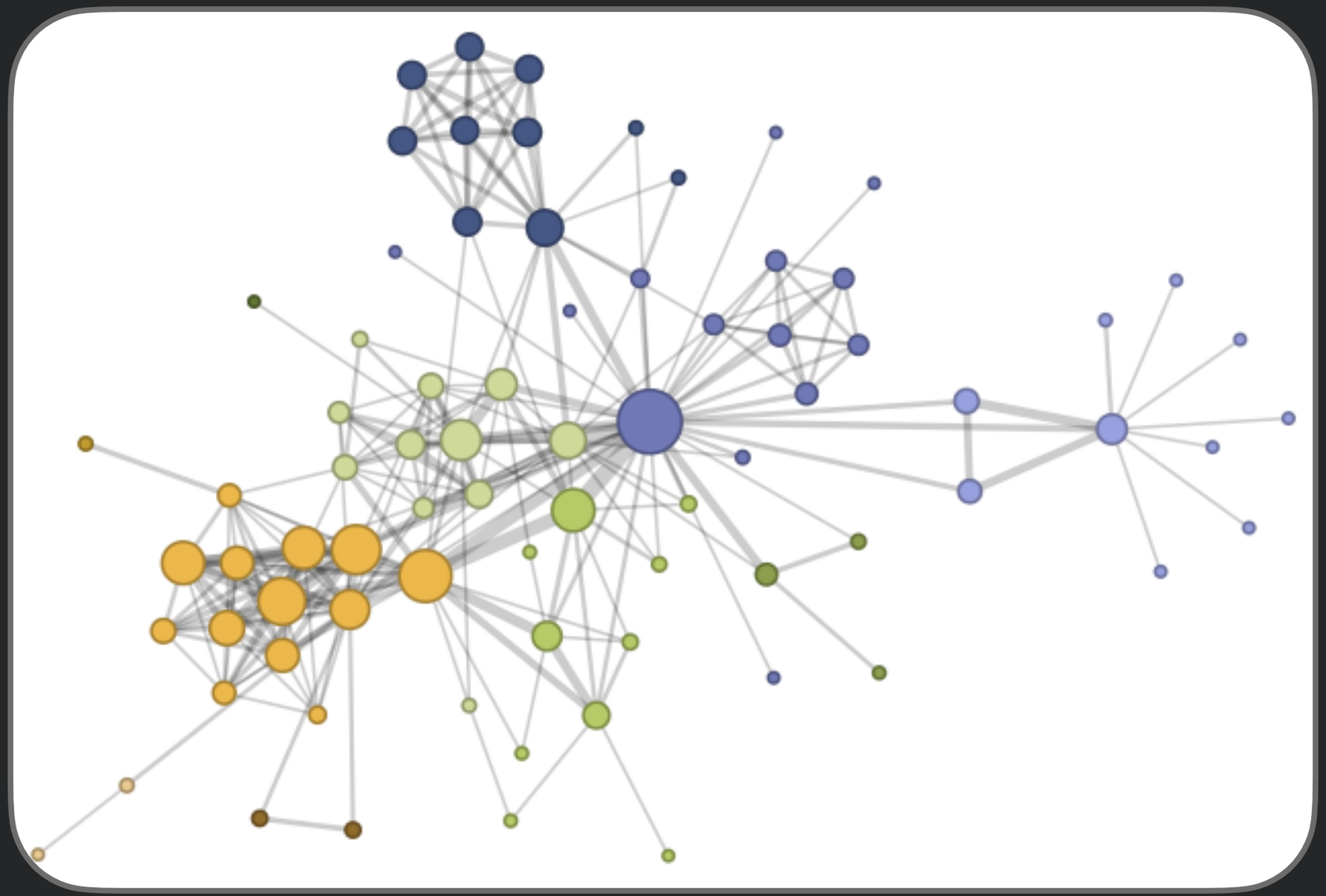
SM-G355H
SM-G7102
Moto G
D6503
GT-I8262
GT-N7100
GT-S7582
G3
Galaxy S5
One
Galaxy Y
C6903
G2
One (M8)
GT-I8552B
S6 Edge
K012
X
ZenFone 5
One
A369i
A536
Moto G
C2105
XL
Z970
7040N
SM-T211
D5803
D6603
Moto E
D6633
Nexus 6
Joy
D5503
OpenSignal
August 2014
August 2015

Networks

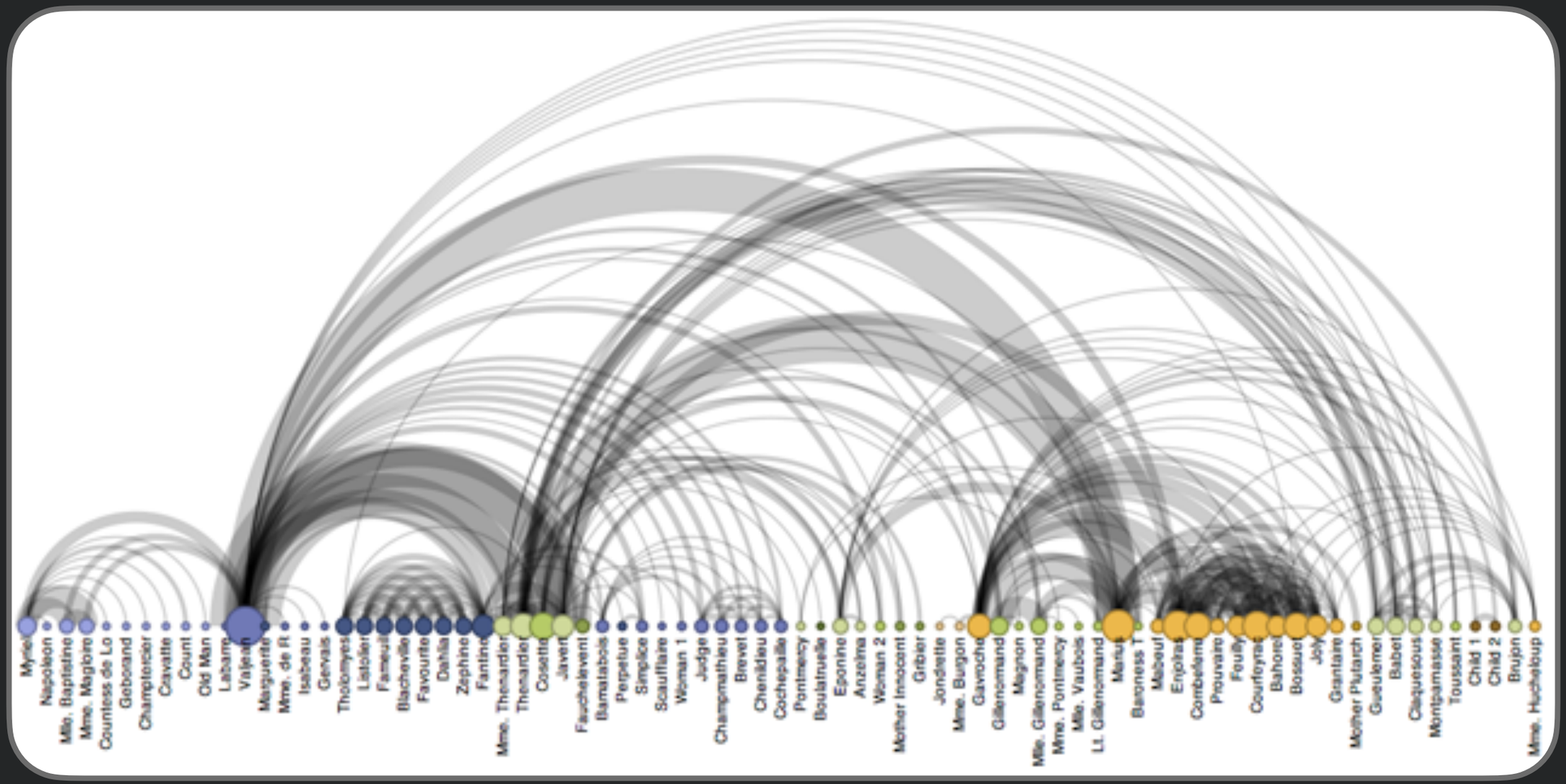
Force-directed Layout

- Edges function as springs, find least energy configuration

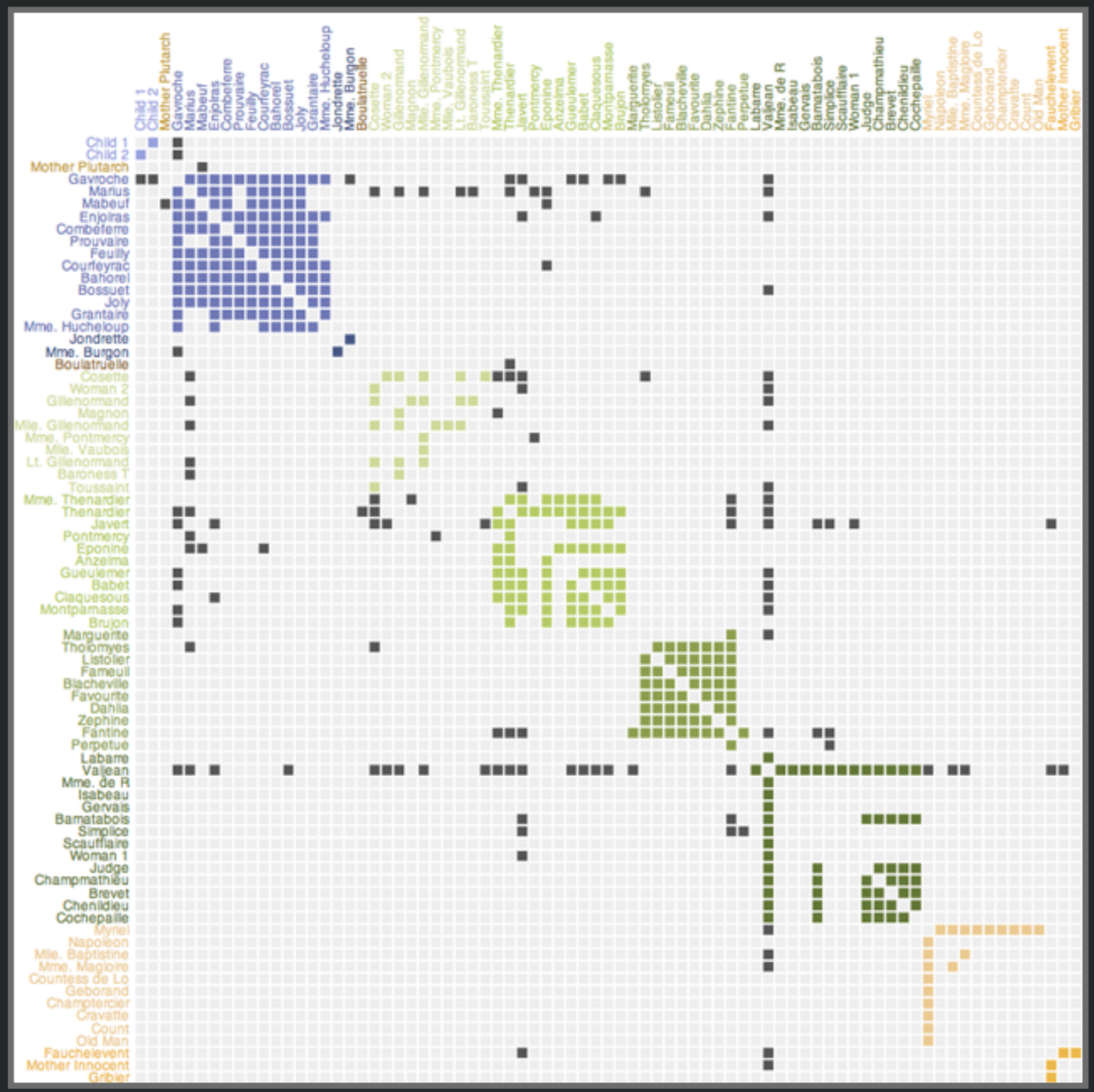


Arc Diagram

- Can support identifying cliques & bridges w/ right order



Adjacency Matrix



Tufte's principles of graphical excellence

- Show the ***data***
- Induce the viewer to think about the substance rather than the methodology
- Avoid distorting what the data have to say
- Present ***many*** numbers in a small space
- Make large data sets ***coherent***
- Encourage the eye to ***compare*** different pieces of data
- Reveal data at several levels of detail, from overview to fine structure
- Serve reasonable clear ***purpose***: description, exploration, tabulation, decoration

Design Principles for Data-ink

- (a.k.a. aesthetics & minimalism / elegance & simplicity)
- ***Above all else show the data***
  - Erase non-data-ink, within reason
    - Often not valuable and distracting
    - Redundancy not usually useful

Interactive Visualizations

- Users often use iterative process of making ***sense*** of the data
  - Answers lead to new questions
- Interactivity helps user constantly change display of information to answer new questions
- Should offer visualization that offers best view of data moment to ***moment*** as desired view ***changes***

Information Visualization Tasks

- ***Overview:*** gain an overview of entire collection
- ***Zoom:*** zoom in on items of interest
- ***Filter:*** filter out uninteresting items
- ***Details on Demand:*** select an item or group and get details
- ***Relate:*** view relationships between items
- ***History:*** support undo, replay, progressive refinement
- ***Extract:*** allow extraction of sub-collections through queries

In-Class Coding Example Exam Problem

Activity: Final Exam Coding Practice

- Imagine you are building an app that implements a ToDo List. You've already implemented the logic adding ToDo Items. Now you'd like to do two things. You'd first like display added ToDo Items to the user. To do so, you decide to create a new child component, ToDoItem, which is initialized with text describing the task. Second, you want to add a button to the ToDo component which, when clicked, deletes the last added task. Implement the Functionality for each of these features.

Class-Based Example: https://replit.com/@kmoran/SWE-432-Final-Exam-Practice-Class#src/App.jsx